3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

This section presents the strategy used to develop, present, and screen remedial alternatives to address contaminated sediments at the Portland Harbor Superfund Site. Alternatives were developed for the Site in accordance with CERCLA, the NCP (40 CFR §300.430), EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA 1988), *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA 2005), and *Guide to Principal and Low Level Threat Waste* (USEPA 1991).

3.1 REMEDIAL ALTERNATIVE DEVELOPMENT STRATEGY

The remedial alternative development strategy for the Portland Harbor Superfund Site presents remedial alternatives evaluated within the FS that are expected to achieve protection of human health and the environment. The NCP [40 CFR §300.430(a)(1)(iii)(C)] provides an expectation that the developed alternatives provide "a combination of methods, as appropriate, to achieve protection of human health and the environment." This FS uses a combination of the remedial technologies identified in Section 2.4. The following areas were delineated to assign applicable remedial technologies in each alternative:

Commented [GF1]: Editorial: Maybe say that the strategy entails development of alternatives that are expected to achieve…?

1. Principal Threat Waste (PTW) areas (Section 3.2),
2. Sediment Management Areas (SMA) (Section 3.3),
3. Swan Island Lagoon (Section 3.4), and
4. Remaining areas of the site (Section 3.5).

3.2 PRINCIPAL THREAT WASTE

The concept of principal threat was developed by EPA in the NCP to be applied on a site-specific basis when characterizing source material (USEPA 1991). Source material is defined as material that includes or contains hazardous substances, pollutants or contaminants that acts as a reservoir for migration of contamination to groundwater, to surface water, to air, or that acts as a source for direct exposure. Further, principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur.

The NCP [40 CFR §300.430(a)(1)(iii)(A) and (C)] establishes the following expectations for principal threat waste:

- EPA expects to use treatment to address the principal threats posed by a site, wherever practicable. Principal threats for which treatment is most likely to be appropriate include liquids, areas contaminated with high concentrations of toxic compounds, and highly mobile materials.

- EPA expects to use a combination of methods, as appropriate, to achieve protection of human health and the environment. In appropriate site situations, treatment of the principal threats posed by a site, with priority placed on treating waste that is liquid, highly toxic or highly mobile, will be combined with engineering controls (such as containment) and institutional controls, as appropriate, for treatment residuals and untreated waste.

No threshold level of toxicity/risk has been established in EPA policy or guidance to equate to a "principal threat." However, EPA guidance (USEPA 1991) does provide that where toxicity and mobility of source material combine to pose a potential risk of 10^{-3} or greater, generally treatment options should be evaluated. In addition, waste contained in drums, lagoons or tanks, or free product [light non-aqueous phase liquids (LNAPLs) or dense non-aqueous phase liquids (DNAPLs)] containing contaminants of concern are also considered PTW. CERCLA, the NCP and existing EPA guidance state an expectation that "treatment [be used] to address the principal threats posed by a site, wherever practicable." This section identifies the PTW areas and presents treatment methods used to reduce their toxicity, mobility, or volume.

Commented [GF2]: Editorial: "that may be used"?

3.2.1 Identification of PTW Areas

Consistent with the NCP and EPA guidance, PTW has been identified based on a 10^{-3} risk, NAPL within the sediment bed, and ~~on~~ an evaluation of mobility of contaminants in the sediment. Consistent with the NCP, EPA expects to use treatment to address the principal threats posed by a site, wherever practicable.

The following criteria were utilized to identify PTW:

Source Material: NAPL has been identified in subsurface sediments offshore of the Arkema and Gasco sites (RM 6 through RM 7.5) as globules or blebs of product in surface and subsurface sediments. NAPL observed offshore of the Arkema site contains chlorobenzene and DDT (dissolved). NAPL observed at the Gasco site contains aromatic hydrocarbons and PAHs. **Figure 3.2-1** identifies locations where NAPL was observed in sediments offshore of the Arkema site and **Figure 3.2-2** identifies the NAPL observed in sediments offshore of the Gasco site.

Commented [GF3]: Due to the contentiousness of the presence of NAPL, particularly at Arkema, it would be good to provide more support in this section. Can you reference relevant memos/data reports?

Commented [GF4]: Consider adding a little additional detail to the legend or figure caption such as what the NAPL delineation is based on (e.g., type of samples, dates of collection). And/or consider plotting sample locations. These NAPL figures have a bit too much of a "trust me" feel for a contentious topic.

Highly Toxic: The following COCs were identified at concentrations exceeding a 10^{-3} risk level at the site:

Commented [GF5]: Are these really the only COCs that were found to exceed a 10-3 risk level in any samples? Or are they the COCs that exceed 10^3 risk in SMAs or some other averaged area? It would be helpful to clarify.

- PCBs
- cPAHs
- DDx
- 2,3,7,8-TCDD
- 2,3,7,8-TCDF
- 1,2,3,7,8-PeCDD
- 2,3,4,7,8-PeCDF
- 1,2,3,4,6,7,8-HxCDF

The highly toxic PTW concentrations for these COCs are presented in **Table 3.2-1**. Surface sediment areas exceeding one or more PTW highly toxic concentration levels are presented on **Figure 3.2-3**. The PTW evaluation focused on surface sediments, which ~~that~~ pose the greatest risk of exposure.

3.2.2 Treatment Technologies

Given the NCP's preference for treatment of PTW, in-situ and ex-situ treatment technologies are considered for the PTW areas as discussed below. Containment technologies may be effective for addressing PTW when treatment technologies do not exist or are not practicable and ~~it~~ the PTW is reliably contained. Containment of PTW will also incorporate reactive materials, such as organophilic clay or activated carbon therefore meeting the preference for treatment.

3.2.2.1 In-Situ Treatment

Activated carbon or organophilic clay may be utilized as potential treatment-based technologies for addressing PTW to reduce contaminant bioavailability (see **Table 2.4-2**). In-situ treatment may be utilized alone or in conjunction with other technologies. Stabilization or solidification may be used to address PTW underneath and around pilings, docks, berthing or mooring dolphins, and other structures servicing active wharfs or shore-based facilities that remain intact. In the federally-authorized navigation channel and FMD areas, in-situ treatment is not compatible with current or future uses due to high flows, turbulence, and the need for future maintenance dredging; thus, in-situ treatment is not considered in these areas.

3.2.2.2 Ex-Situ Treatment

For PTW material that is removed, four treatment technologies were retained for assignment and further evaluation:~~,~~ particle separation, cement solidification/stabilization, sorbent clay solidification/ stabilization, and low temperature thermal desorption (see **Table 2.4-2**).

3.3 SEDIMENT MANAGEMENT AREAS

The SMAs are defined by contaminant concentrations exceeding a specific COC threshold. The SMAs represent areas of localized concentrations of surface sediment contamination identified during the RI where MNR is not considered to be effective in reducing concentrations of COCs. Therefore, containment (capping) or removal (dredging) technologies will be considered in these areas to reduce risks.

Determining the appropriate dredging or capping technology to assign is dependent on a number of site-specific characteristics and environmental conditions. These factors include current and reasonably anticipated future land and waterway use, areas of erosion/deposition, sediment bed slope, infrastructure such as docks and piers, and physical sediment characteristics.

Commented [GF6]: 1,2,3,4,6,7,8-HxCDF is reported in this table, but is not reported in the HH risk table (Table B1). Instead, it appears that 1,2,3,4,7,8-HxCDF is reported. Is one of these a mistake? Aside from this issue, none of the HH risk values in Table B1 for this contaminant result in 0.04, which is the value reported in the table cited here.

We would appreciate clarification on this discrepancy and/or would recommend changes to the appropriate table to correct this discrepancy.

Commented [GF7]: Similar to our comment in the paragraph above, how were these areas determined? Do these areas encompass all points with exceedances of the 10^3 risk level, or is a SWAC calculated, and SWAC needs to be greater than the 10^3 risk level? If it's the latter, how was the area for the SWAC determined?

Commented [GF8]: Is this what you mean? Or did the PTW evaluation focus only on the surface sediments that pose the greatest risk of exposure? If it's the latter, how were these areas selected?

Commented [GF9]: It looks like these options are considered containment in place, not in-situ treatment, in the referenced table. We understand that these technologies can fall under both of these categories, but it would be helpful if the text or table clarified that.

3.3.1 Identification of SMAs

Dredging and/or capping technologies are less cost-effective in risk reduction at relatively low contaminant concentrations compared to higher concentrations. Therefore, this FS focuses on applying dredging and capping to areas of higher contaminant concentrations. These areas are determined by identifying the most widespread contaminants (termed "focused contaminants") and those that pose the highest risks. A range of contaminant concentrations for these focused contaminants is developed to delineate concentration contours for each alternative.

3.3.1.1 Focused Contaminants of Concern

Contaminants of concern (COCs) were identified in Section 2.2.1. A subset of focused COCs was identified to allow for the delineation of areas for consideration of dredging and/or capping. The focused COCs are used only for the development of the SMAs; all COCs will be considered during the detailed evaluation of remedial alternatives presented in Section 4. The distribution of these focused COCs encompasses the majority of the spatial extent of contaminants posing risks as identified in the baseline risk assessments.

The focused COCs selected for this FS are:

- PCBs
- Total PAHs
- 1,2,3,7,8-PeCDD
- 2,3,4,7,8-PeCDF
- 2,3,7,9-TCDD
- DDx

3.3.1.2 Remedial Action Levels (RALs)

RALs are contaminant-specific sediment threshold concentrations used to identify areas of surface sediments where capping and/or dredging will be evaluated and are the basis of the SMA boundaries. The RALs were developed considering the relationship between the spatial extent of contamination exceeding the RAL concentration (acres of capping or dredging) and the surface-area weighted average concentrations (SWACs). With the exception of DDx, this relationship was calculated on a site-wide basis. The RAL curves for each focused COC are presented in **Figures 3.3-1** through **3.3-6**.

A range of RALs consisting of six different concentrations was developed for each focused COC decreasing from B through G. These concentrations resulted in increased area capped/dredged from B through G. The following information was considered in selecting RALs:

- Maximum Incremental Reduction of the SWAC. The point on the curve where further reductions in SWAC concentrations results in minimal increase in acres capped/dredged. The B RAL was identified just past this point on the curve.

Commented [GF10]: Is this what you mean, or do you mean compared to other technologies?

Commented [GF11]: This is good justification for selection of the focused COCs. However, can we also say something about the relative risk posed by these focused COCs (not just the spatial extent)?

Commented [GF12]: We believe that this is the first time the SWAC concept is introduced. It should be explained further here. We also suggest clarifying that, in this case, the SWAC is for immediately following remediation and assumes background concentrations in remediated areas

Commented [GF13]: This exception warrants some discussion. Why DDx (and it's not explained below either)? Also, it looks like there is a figure for site-wide DDx, but also the localized one. Were the RALs selected based on the localized curve but then also plotted site-wide?

Commented [GF14]: The RAL curves will be difficult for first-time readers to understand. For instance, we don't think it's clear that the gray numbers are the RAL concentrations. As noted in our comment above, it's not clear that the background (replacement) value is used in the remediated areas to calculate the SWAC. Units in the SWAC and Area boxes at the top would be useful. An explanation of the SWAC floor is needed. Also, why does the site area always equal the area above SWAC floor - shouldn't the site area be the same area for all RAL curves? Maybe you just need to define "site area".

Commented [GF15]: We like the attempt to describe the rationale for the various RAL alternatives. However, the alternatives don't always seem to line up on the curve exactly as described, and the selection of the location of these different points (e.g., knee of curve) seems a bit subjective. We are undecided whether it's better to provide the rationale even if the placement of the points don't exactly conform or if it's better to leave the discussion more general (keep bullets, but soften language on how B-G were selected).

- Marginal Incremental Reduction of the SWAC. The point on the curve where further increases in acres capped/dredged do not result in discernable reductions in SWAC concentrations. The G RAL was identified prior to reaching this point on the curve.

- Knee of the Curve. The inflection point of the curve where incremental increased acres capped/dredged becomes greater than the incremental reduction of the SWAC. The E RAL was identified at this point.

- Spatial Distribution. An additional two points (RALs C and D) were identified on the curve that were spatially distributed between points B and E and another point (RAL F) was identified between points E and G.

PCBs
The selected PCB RALs and the resulting SWACs and acres are presented in **Table 3.3-1.** The location of these PCB RALs is presented on **Figure 3.3-7**.

Total PAHs
The selected total PAH RALs and the resulting SWACs and acres are in **Table 3.3-2**. The location of these total PAH RALs is presented on **Figure 3.3-8**.

Dioxins and Furans
Several dioxin/furan PRGs are below the method detection limit (MDL). In addition, the low density of dioxin/furan samples requires interpolation across large areas where no data are available, creating a greater likelihood that specific locations within a designated RAL footprint is a "false positive." Because the PRGs are below the MDL, the interpolation process will essentially "map" the entire site. This necessitated an alternate approach in the development of the dioxin/furan RALs for the FS, which is described below:

2,3,7,8-TCDD: Only five samples were identified for RALs B, C and D, as initially defined. Thus, a single value (equivalent to the D RAL) will be used for all three alternatives. Due to the number of non-detect results that would be greater than any potential F or G RALs, the E RAL will be used for the E, F, and G Alternatives.

1,2,3,7,8-PeCDD: Due to the number of non-detect results that would be greater than any potential E, F or G RALs, the D RAL will be used for E, F and G alternatives.

Commented [GF16]: In the relevant figure, Alternative D is plotted as its own category, followed by Alternatives D, E, F, and G. Is the Alternative D label intended to read Alternative C?

2,3,4,7,8-PeCDF: Only a single sample was identified as representing possible B, C, D, and E RALs. Thus, the E RAL will be used for the B, C and D alternatives, and the F RAL will be used for the E and F alternatives.

The selected dioxin/furan RALs and the resulting SWACs and acres are presented in **Table 3.3-3**. The location of these dioxin/furan RALs is presented on **Figures 3.3-9** through **3.3-11.**

DDx

The selected DDx RALs were determined based on consideration of the distribution of surface sediment contamination within the localized area of RM 6.6 – 7.8 west and evaluated on a site-wide basis. The RALs for DDx and the resulting SWACs and acres are presented in **Table 3.3-4**. The location of these DDx RALs is presented on **Figure 3.3-12**.

Commented [GF17]: Similar to comment above, it's not clear why you are presenting it site-wide and for the localized area for DDx but not for other focused COCs.

Summary of RALs

Final RALs for the focused COCs are presented in **Table 3.3-5**. Surface sediment data for each focused COC were interpolated using a Natural Neighbor algorithm (a commonly used geostatistical approach based on Theissen polygons). A spatial grid was created consisting of 10-foot by 10-foot pixels, where each pixel was associated with a measured or interpolated concentration. Polygons were drawn around contiguous regions where the interpolated data exceeded the RAL concentration. SMAs were developed by aggregating the concentration contour footprints for six focused COCs; PCBs, total PAHs, DDx, 1,2,3,7,8-PeCDD, 2,3,4,7,8-PeCDF and 2,3,7,8-TCDD for Alternatives B through G. SMAs are shown on **Figure 3.3-13**.

3.3.2 Application of Technologies

The technology application process considers site characteristics in the SMAs so that remedial approaches most appropriate for site conditions (anthropogenic and environmental) are developed and applied in particular areas. EPA's 2005 Guidance (particularly the series of "highlights" of site characteristics conducive to particular remedial approaches; Highlight 4-2, 5-1, 6-2, and 7-2) and other resources describe site characteristics consistent with remedial approaches (EPA 1991; USACE 2008; ITRC 2014).

The technology screen followed a two-step process. The first step uses a decision tree (**Figure 3.3-14a**) and multi-criteria decision matrix (**Figure 3.3-14b**) to assign a preferred technology step within specific grid cells (pixels) throughout the site. The second step transforms segmented and isolated pixel-level technology assignments (resulting from a strict interpretation of the GIS output) to a predominant technology assignment by applying a smoothing algorithm that eliminates some of the small scale variability in the output and assigns a technology to the majority of the pixels within each SMA.

Commented [GF18]: A few comments on the matrix:
1) We are not sure of the logic of why armored capping gets a 0 if moderate to heavy debris is present, and EMNR/cap gets a 1. It seems like they should both be 0 or both be 1, but perhaps there's a good reason for the distinction.
2) We would think that 0 (not -1) would be appropriate for dredging if an area is depositional, since deposition is not an impediment to dredging.
3) As commented elsewhere, since no areas were classified as rock, cobble, or bedrock, it may be simpler to remove this factor, unless you are thinking that this substrate may be encountered during pre-RD sampling and want to leave it in for that reason.
4) The note with the asterisk is a bit confusing at first glance, that grid cells outside SMAs are assigned EMNR. My understanding is that the only areas outside SMAs that will be actively treated are PTW areas. It may help the reader if you include a note in the table and/or text explaining that these areas then undergo another decision-tree process to determine final FS technology selection. This would ensure that people don't get confused and think that EMNR is applied widely to areas outside of SMAs.
5) Over-arching comment about the matrix: does EPA feel that the current system introduces any biases toward certain techniques? For instance, the highest score that dredging could receive is greater than the highest scores that armored cap and EMNR/cap can receive. Does this introduce a bias toward dredging? Also, is it appropriate to weight all factors equally?
6) Several other comments related to the matrix are provided as separate comments in the following sections.

3.3.2.1 Technology Assignment Decision Tree

The technology assignment decision tree (**Figure 3.3-14a**) provides two off-ramps for areas that are within the federally-authorized navigation channel (navigation channel) or designated as future maintenance dredge (FMD) and areas that have been subject to final EPA remedies.

Navigation Channel and Future Maintenance Dredge Areas

Due to minimum water depth requirements, the placement of thin-layer sand covers, in-situ treatment amendments, and conventional or reactive caps are considered incompatible with current and future waterway uses. The current authorized elevation for the lower Willamette River is -43 feet CRD although the navigation channel is currently only maintained to -40 feet CRD.

Commented [GF19]: Given this, how are the assumptions about dredging (BMPs including placement of thin-layer sand caps) discussed in section 3.3.4.1 (Residuals) below applied to Nav and FMD areas?

Future channel depths could be increased to -48 feet CRD. Therefore, this channel depth was assumed with an additional 3-foot advanced maintenance/overdredge allowance and a 2-foot-thick operational buffer between the top of in situ caps. Given these assumptions and restrictions and taking into consideration the thickness of any placed material, only dredging is considered a viable technology in these areas. Even in the case of dredging, navigation and maintenance dredge depth requirements will need to be considered during the design and implementation of dredging activities and the placement of any thin layer covers for residual management. The FMD areas were develop from estimates of likely future navigation depth requirements and potential future maintenance dredging depths near and around docks based on information regarding vessel activity, dock configuration and future site uses. The boundaries of the navigation channel and FMD areas within the Site are~~is~~ presented on **Figure 3.3-15**. A description of how the FMD areas were derived is provided in Appendix C.

Commented [GF20]: Do you mean that it is reasonable to expect that in the future the authorized depth could increase to -48 feet? Or is this just -43 feet currently authorized plus the -3 feet plus -2 feet? Confusing as written.

Commented [GF21]: Has EPA assessed some representative changes in the cross sections relative to the proposed remediation areas? Deepening the channel will also necessitate a greater lateral extent of the side slopes, so it is not just thinking about the bottom of the channel. Deepening to accommodate larger vessels also might mean that there will be longer vessels that require changes to the existing channel layout, particularly where vessels need to turn. Has this been considered? If these things have been at least thought about, some mention should be made.

Separate NPL Sites with Final Remedies

Separate NPL sites within the Portland Harbor Site, Gould and McCormick and Baxter, where a final remedy has been implemented have been excluded from this analysis. This exclusion applies solely to the McCormick and Baxter site where the cleanup action included placement of a sediment cap. The location of the McCormick and Baxter sediment cap is presented on **Figure 3.3-16**.

Commented [GF22]: Why is this mentioned if the next sentence says that the exclusion applies only to M&B? Confusing as written.

3.3.2.2 Multi-Criteria Decision Matrix

The multi-criteria decision matrix was developed as a non-biased and reproducible method for assigning capping and dredging technologies based on site characteristics. Each technology is scored based on multiple criteria related to hydrodynamics, sediment bed characteristics, and anthropogenic conditions. The scoring approach and criteria are presented on **Figure 3.3-14b**.

As presented on **Figure 3.3-14b**, capping and dredging technologies were assigned a score of +1, 0, -1, or NC (not considered) for each criteria described below. The score reflects whether a given site characteristic favors application of a given remedial technology (+1), is neutral to the application of a remedial technology (0), limits application of a remedial technology (-1), or NC based on the given site characteristic. EMNR and engineered caps were scored equally, and were not considered appropriate in wind and vessel induced wave zones, where slopes are greater than 15 percent, and in propwash zones. Each pixel was compared against the criteria and if the response was yes for each criterion then the score were assigned for each technology. The values assigned for each criterion were then summed for each technology and the technology

Commented [GF23]: It sounds like if any one of these factors was met, EMNR/engineered cap was automatically excluded. We think this point needs to be made more explicit in the text and/or matrix (perhaps in the note defining Not Considered

Commented [GF24]: Editorial: Scores were or score was

Commented [GF25]: This sentence is unclear. What do “response” and “yes” mean in this context? Does “each technology” refer only to EMNR and engineered cap?

with the highest total score was assigned to the pixel. The completed scoring matrix is presented on **Figure 3.3-14b**.

3.3.2.2.1 Hydrodynamics

Criteria evaluated in the assignment of remedial technologies include wind wave zones, sediment erosion potential, sediment deposition rate, and water depth. Appendix C provides further detail on how the GIS layers were developed for use in the technology assignment process.

Wind Wave Zones and Erosion

Two criteria were used to indicate whether an area was erosive: wind and vessel wake generated waves and shear-stress on bottom sediments during high flow events. These criteria consider the potential for material placed in the river to be eroded and transported downstream.

Commented [GF26]: It's not clear how wind wave zones and shear-stress are scored. Figure 3.3-14b shows that they share scores. Are they each evaluated independently and each contribute their own score to the total? Or does one or both criteria need to be satisfied to be considered wind/wave zone/erosive, and then there is only one score?

Nearshore areas may be subject to wave action generated from wind or vessel traffic. The areas subject to wave action are dependent on river stage fluctuations. For this FS, the wave zone has been defined as areas with surface sediment elevations ranging from 0 to13 feet NAVD88 based on an analysis presented in Appendix C. These areas are not conducive to depositional MNR, EMNR, in-situ treatment, or unarmored sediment caps due to wave-induced erosion potential. Wind and wake generated wave zones are presented on **Figure 3.3-17**.

Bedded sediments are prone to erosion and transport when shear stress on the sediment bed generated by water flow exceeds the critical shear stress of the sediment bed. In this analysis, the shear stress values during a 2-year flow event were determined from the Sedflume system results and the HST model (refer to the remedial investigation report Section 3 for further details); these values were then compared to the critical shear stress values of the bedded sediment. Areas where the shear stress of the 2-year event exceeds the critical shear stress of the bedded sediment are considered erosive. Note that the sediment bed area impacted by a 2-year event is smaller than the area impacted by a 100-year event because the spatial area of the sediment bed considered erosive is positively correlated with the return interval. The 2-year return interval was considered reasonable because it delineates areas that are routinely impacted by a flow event rather than areas that rarely experience flows that exceed the shear stress of the bedded sediment. Estimates of shear stress throughout the Site are shown on **Figure 3.3-18**.

Commented [GF27]: It would be helpful to provide some additional direction on how to interpret this figure, either here or in the figure. How do the numeric intervals correlate with whether an area is erosive? This may be in Appendix C, but it's basic information that should be made more accessible.

If an area is considered erosional, dredging is scored higher (more favorable) than capping, which in turn is scored higher than a thin sand layer associated with EMNR because sediment caps can be designed to withstand erosive forces.

Deposition

This criterion evaluates the sediment deposition rate, which is important for stabilization of placed material. Two factors were evaluated to determine if an area was depositional. The first is based on the difference in elevations between bathymetric surveys and the second is based on the ratio of the surface and subsurface sediment concentrations.

The bathymetric surveys from January 2002, May 2003 and January 2009 were used in this evaluation. The difference between the January 2002 and January 2009 surveys ~~were~~ was evaluated to represent the long-term changes in bathymetry. The difference between the May 2003 and January 2009 survey was also evaluated to understand the uncertainty in long-term deposition rates. Based on the accuracy of the surveys (+/- 0.5 feet) and the time frame being considered (7 years or 5.67 years depending on whether the January 2002 or May 2003 is selected as the initial survey date), the minimum detectable sediment deposition rate was estimated to range between 2.2 and 2.7 cm/yr. Based on this analysis, a sediment deposition rate of 2.5 cm/year was selected as the threshold for identifying the area as depositional. Areas of the Site with sediment deposition rates greater than 2.5 cm/year are shown on **Figure 3.3-19**.

Depositional processes over time are assumed to have led to cleaner sediments overlaying more contaminated sediments. The threshold for this evaluation was a surface to subsurface contamination concentration ratio of 0.5, where surface sediment is considered the upper 40 cm, for interpolating surface and subsurface concentrations for the focused COCs. These areas are presented on **Figure 3.3-20**.

If an area is considered depositional, capping is scored higher than dredging indicating that depositional environments are conducive for containment technologies that rely on isolation.

Shallow

Water depth in nearshore areas was also considered due to the potential loss of shallow water habitat, increase in the flood rise zone, and the conversion of submerged lands to upland following placement of material in the river. The shallow water criterion of 4 feet NAVD88 was based on an assumed cap thickness of 3 feet (~~of~~ if capping were to be applied) and a MLLW elevation of 7 feet NAVD88. This will allow for maximum thickness of material placed in the river that remains submerged at the MLLW. While there may be opportunities to place material above the 4 feet NAVD88 elevation, they would likely require special design considerations and are best addressed as part of remedial design rather than as part of the technology assignment scoring approach. Shallow water zones are depicted on **Figure 3.3-21**.

Water depth is less critical for implementation of dredging-based technologies due to the generally shallow water conditions associated with the SMAs. Access to nearshore areas is achieved by dredging from the shore or the use of shallow draft barges and long-reach excavators. Therefore, dredging is scored higher than EMNR or capping (which is scored as neutral), followed by armored caps.

Commented [GF28]: Based on Figure 3.3-14b, we're assuming that you only need one criteria to show deposition in order for the area to be considered depositional, but this doesn't appear to be stated in the text. You may want to clarify in this paragraph or last paragraph in this Deposition section.

Commented [GF29]: In Figures 3.3-14b and 3.3-20, this is written as subsurface to surface ratio of 2. We suggest you describe this in a consistent manner.

Commented [GF30]: How do river water level trends (e.g., due to climate change) and low-water level years factor into this definition of shallow areas? We would like these factors to be discussed in this section to justify the shallow water designation.

Commented [GF31]: We request that this definition of shallow water be rectified with the NMFS definition of 20 feet below MLLW.

Commented [GF32]: We find this discussion of shallow waters confusing. If we are understanding it correctly, one could place a 3-foot cap in waters shallower than 4 feet NADV88 if dredging occurred first. For instance, at 1 foot NADV88, one could dredge 3 feet and place a 3-foot cap. Correct? Maybe you just need to state that placing material above the 4-foot elevation would require dredging first or other special design considerations.

Commented [GF33]: Does this figure plot areas ≤7 feet deep or ≤4 feet deep? It's not clear from the text. Why is 7 feet NAVD88 referenced here? It would be useful to add depth criteria to the figure. We also suggest that you consider how you are expressing depths. Earlier, in the context of navigation channels, you use negative numbers (e.g., -40 feet), whereas here you don't include the negative signs.

3.3.2.2.2 Sediment Bed Characteristics

Sediment bed characteristics considered in the evaluation include sediment bed slope and the presence of cobbles, armor rock, and bedrock.

Slope

Sediment slope and slope stability are considered relevant for all remedial technologies. Sediment slope must be considered during the placement of a thin sand layer EMNR material, in-situ treatment amendments, and capping materials. In addition, slopes must be considered during the design and implementation of dredging-based remedies. Although caps can be engineered for slopes up to 40 percent, special cap design and placement methods may be required when the slope is greater than 30 percent. Thin sand layers can be placed on slopes up to 15 percent without special considerations. At steeper slopes, the special considerations required for thin layer placement warrant a more engineered design. As a result, two separate slope criteria have been established: 15-30 percent and greater than 30 percent. These areas are presented on **Figure 3.3-22.**

At slopes between 15 and 30 percent, dredging and armored capping were scored equally, recognizing that both would encounter some but not a substantially different degree of challenges associated with implementation. At slopes greater than 30 percent, armored capping was scored less than dredging, recognizing the impact of slopes on cap stability and the increase in design considerations to offset the impact. EMNR and engineered caps were not considered on slopes greater than 15 percent because of the potential lack of stability and impact on performance.

Cobbles, Rocks and Bedrock

The presence of cobbles, rock, and bedrock do not typically limit EMNR, capping, or in-situ treatment because the thin layer cover, cap, or in-situ treatment amendment is placed on the sediment surface and any necessary mixing occurs naturally (ITRC 2014). Their presence may limit short-term effectiveness of dredging-based remedies by impeding hydraulic dredging equipment, interfering with bucket closure and resulting in increased contaminant release rates (USACE 2008), or limiting placement of sheet pile containment during dredging. Finally, the presence of bedrock can limit the full removal of contaminated sediments due to cracks and crevices that trap contaminated sediments and increase the amount of generated residuals and contaminated sediment release rates. However, there are currently no identified areas in the site where areas of cobble, rock, or bedrock are present, and therefore scoring was not affected.

Commented [GF34]: We suggest that you drop this criterion from the table if it wasn't used. This would help simplify the matrix. You can explain in the text that it was considered, but then not applied and why.

3.3.2.2.3 Anthropogenic Influences

Anthropogenic influences considered in the matrix include structures and pilings, heavy debris, and propeller-induced erosion (propwash).

Structures and Pilings

Structures and pilings are present throughout the site. These structures pose operational and implementation constraints for all of the remedial technologies. In particular, dredging is affected because offsets needed to protect structural stability require special design considerations or could require removal of structures. In areas with structures and pilings, capping and EMNR are scored higher than dredging. The locations of structures and pilings are presented on **Figure 3.3-23**.

Propwash

Erosion due to propwash can limit the effectiveness of EMNR and may also require special design considerations for capping. Propwash areas are evaluated only for large vessels and tugboats; ~~,~~ propwash from recreational craft is considered insignificant. Based on results of modeling presented in Appendix C, propwash disturbance is generally limited to the upper 30 cm (approximately one foot) of sediments and is most prevalent in shallow portions of the navigation channel and in berthing areas. However, the modeling indicated a maximum disturbance depth of over 6 feet. Further, up to 3 feet of scour was estimated to occur at the U.S. Moorings site within Portland Harbor during a 2003 sediment investigation (URS 2003). Propwash areas based on the modeling effort are presented on **Figure 3.3-24**.

Propwash has the greatest impact on EMNR, caps, and in-situ treatment because the erosive forces can erode and disperse thin layer sand covers and in-situ treatment amendments. As a result, EMNR and engineered caps are not considered viable in propwash zones. However, armored caps can generally be designed to prevent propwash-induced erosion, and it is not a significant factor for dredging (although propwash-induced erosion must be considered for any thin layer covers for residual management). In propwash areas, dredging is scored higher than armored capping, followed by EMNR/capping.

Debris

A high resolution sidescan sonar survey was conducted on the lower Willamette River in 2008 to determine the approximate distribution of debris in the river channel and along both banks of the river. The sidescan sonar survey area extended from RM 1 to RM 12.2, and extended one-half mile into Multnomah Channel. Debris was identified throughout Portland Harbor. A detailed presentation of sidescan sonar targets and their locations are provided in the *Lower Willamette River Sidescan Sonar Data Report* (Anchor QEA 2009b). Because the sidescan sonar survey identified pilings as well as debris, sidescan sonar targets ~~classified~~ identified as pilings were classified as structures for the purpose of this FS.

Heavy debris can lead to reduced dredging production rates and increased contaminant release rates (USACE 2008). Moderate to heavy debris areas are presented on **Figure 3.3-25**. In areas where moderate to heavy debris is present, dredging is scored low because of the need for a debris removal pass and because debris limits dredging effectiveness by increasing generated residuals and releases. While the presence of debris can affect cap placement and function, such issues can be addressed through greater cap thicknesses. Therefore, capping is scored higher than dredging.

Commented [GF35]: Editorial: The wording is unclear. Please check whether our suggested edits capture your meaning.

Commented [GF36]: Why was 40 objects chosen as the cutoff? What sort of range exists above 40 objects? This is a good example of where a simplistic yes/no approach with equal weighting with other factors could result in great influence on the matrix. These choices need to be discussed, perhaps in Appendix C.

3.3.2.3 Scoring Results

Figure 3.3-26 depicts how the scores derived from the technology assignment matrix GIS processing are further evaluated. There are three scoring outcomes: a technology receives the highest score; technologies are tied; or an area does not receive a score (an outcome when the area does not achieve the threshold for any of the criteria). When scores are tied, the tie goes to the least intrusive remedy; EMNR and capping are less disruptive than armored capping, which in turn is less intrusive than dredging. Within SMAs, areas identified as EMNR have been reclassified as engineered caps due to design considerations necessary to ensure adequate isolation of the higher contaminant concentrations. In addition, areas outside SMAs assigned EMNR undergo a final evaluation to determine whether, during a 25-year return flow event, the area is within a zone where shear stresses on the sediment bed exceed the shear stress of a medium sand, which is expected to be representative of thin layer cover material. In such instances capping is indicated as the assigned technology. This ensures EMNR is not applied in an area prone to erosion in the short-term.

Figures 3.3-27a-f present the technology assignments for each set of SMAs (B through G) and show that the acres assigned to dredging are primarily within the navigation channel and future maintenance dredge areas. Nearshore areas tend to be a mix of technologies: 1) dredging along the shoreline in shallow areas subject to wind and vessel wake action, and 2) capping and EMNR farther offshore and beneath structures. A summary of the acreage assigned to capping, dredging and EMNR technologies are presented in **Table 3.3-6**.

3.3.3 Containment Technologies

Three containment technologies were retained for assignment and further evaluation, engineered caps, reactive caps, and armored caps (see **Table 2.4-2**). A review of a variety of FS and design-level cap configurations indicates that caps for sediment sites typically range between 2 and 3 feet in thickness depending on site-specific conditions related to erosive forces, chemical isolation requirements, and habitat requirements. Cap thickness is dependent on site-specific considerations that will be addressed in remedial design.

3.3.3.1 Engineered Caps

Containment involves leaving a portion of the contaminated sediment in place and isolating these materials from the environment through the use of engineered caps. Several major considerations drive the conceptual design, cost estimates, and feasibility. The following cap designs were assumed:

Shallow Areas

- Physical Isolation Layer: 30 inches of sand.
- Stabilization Layer: 6 inches of beach mix.

Intermediate Areas

Commented [GF37]: It seems like the overlays for consideration are just relevant to capping. If so, we suggest that you state that in the figure.

Commented [GF38]: Under what circumstances could this happen? What would be the outcome if there were no score?

Commented [GF39]: The 5 Tribes would like to know how frequently a tie arises and what would be the result of selecting the more intrusive remedy.

Commented [GF40]: We assume that EPA considered EMNR to be less intrusive than capping. If so, this should be stated.

Commented [GF41]: Why is 25 years used here, while 2 years is used for previous determination of erosive areas? This merits some discussion or footnote.

Commented [GF42]: For the "Cap/EMNR" heading in table, you may want to specify engineered cap to distinguish from armored cap. Also, reactive caps are mentioned below but previously not discussed much. How do they fit into this table?

Commented [GF43]: Our understanding of this term is that all the caps discussed in the FS are types of engineered caps. EPA uses this term when not discussing one of the special types of engineered caps. If that is correct, that should be stated, probably in Section 2, and maybe in Section 3 as well.

- Physical Isolation Layer: 36 inches of sand

3.3.3.2 Armored Caps

Certain areas in the river would require armoring on caps to reduce erosion, particularly after large storm events. Re-deposition of fine-grained material in capped and armored areas is anticipated to occur over time, making the armored areas similar in surface grain size to non-armored areas. The following cap design was assumed for both shallow and intermediate areas:

- Physical Isolation Layer: 24 inches of sand.
- Stabilization Layer: 12 inches of armor stone.

3.3.3.3 Reactive Caps

Physical isolation of contaminated sediments may require an additional reactive layer when the vertical movement of dissolved contaminants by advection (flow of ground water or pore water) through the cap is possible. In these instances, the sorptive capacity of the cap material will determine the ability to retard contaminant flux through the cap. The following cap designs were assumed:

Shallow Areas

- Chemical Isolation Layer: 12-inch layer comprised of sand mixed with 5 percent activated carbon.
- Physical Isolation Layer: 18 inches of sand.
- Stabilization Layer: 6 inches of beach mix.

Intermediate Areas

- Chemical Isolation Layer: 12-inch layer comprised of sand mixed with 5 percent activated carbon.
- Physical Isolation Layer: 24 inches of sand

3.3.3.4 Armored Reactive Cap

Within certain areas in the river where reactive caps are needed, armoring to reduce erosion, particularly after large storm events may also be necessary. The following cap design was assumed for both the shallow and intermediate areas:

- Chemical Isolation Layer: 12-inch layer comprised of sand mixed with 5 percent activated carbon.
- Physical Isolation Layer: 12 inches of sand.
- Stabilization Layer: 12 inches of armor stone.

3.3.3.5 Additional Cap Considerations

The following considerations apply to the assumed cap designs throughout the site.

Areas with Principal Threat Waste

EPA expects to use treatment to address the principal threats posed by the Site, wherever practicable, consistent with the NCP (40 CFR §300.430) and EPA guidance. If sediment classified as containing PTW is located in an area designated for capping, then a reactive cap will be assumed for that area.

PTW that can be Reliably Contained: Representative site conditions and capping options were modeled to determine the maximum concentrations of PTW material that would not result in exceedances of AWQC in the sediment cap pore water after a period of 100 years. Contaminants modeled were chlorobenzene, dioxins/furans, DDx, naphthalene, PAHs, and PCBs. A description of this modeling effort is provided in Appendix D, and the results are summarized in **Table 3.3-7**. The areas where PTW ~~that~~ would not be reliably contained are presented ~~on~~ in **Figures 3.3-28** and **3.3-29.**

Organoclay reactive caps are assumed at locations where NAPL is present and where containment is assigned. Organoclay has recently been used as an amendment in the capping of NAPL at the McCormick and Baxter site in the Willamette River within the Portland Harbor Site. The following cap design was assumed for both the shallow and intermediate areas:

- Chemical Isolation Layer: 12-inch layer comprised of sand mixed with 20 percent activated carbon.
- Low Permeability Layer: clay (e.g., AquaBlok)
- Physical Isolation Layer: 18 inches of sand.
- Stabilization Layer: 6 inches of armor stone.

Areas with Contaminated Groundwater

COC transport through a cap is partially driven by advective forces. While p~~P~~ore water seepage rates for the entire Site are not known, available information indicates rates are higher on the western side of the Willamette River due to a greater groundwater hydraulic head than found on the eastern side of the river. To account for the higher seepage rates, reactive caps or thicker engineered caps are assumed on the western side of the river or at eastern locations with similar characteristics.

While the full extent of groundwater contamination at the site is currently unknown, available information in the RI and the ODEQ Source Control Reports indicates that contaminants are being transported to the river via groundwater flow. Even in instances where a groundwater plume has been controlled in the uplands, there may be a portion of the plume that has moved beyond the control point and continues to seep into the river. Accordingly, all areas with known groundwater contamination are assumed to require an in-river reactive cap to reduce the contaminant flux and limit potential exposures. Areas where contaminated groundwater may seep through riverbanks are also assumed to require a reactive cap.

Commented [GF44]: Except if concentrations modeled in Appendix D are exceeded? It's unclear how the modeling results factor into this assumption.

Commented [GF45]: Editorial: More appropriate to call this section PTW that cannot be reliably contained?

Commented [GF46]: We assume that the contaminants labeled "can be reliably contained" can be contained at all concentrations found at Portland Harbor. However, a note to this effect might be worthwhile.

Commented [GF47]: The appendix described this as a screening model (which suggests certain limitations and perhaps general assumptions), but its results are being used to make major decisions. If this is an appropriate model to make FS-level decisions, that should be stated, maybe in the appendix (e.g., This screening model is sufficiently rigorous to be used for decision-making at the FS phase. More rigorous modeling will be conducted as needed in remedial design.).

Commented [GF48]: It's not clear whether these are areas whose concentrations exceed those modeled in Appendix D (Table 3.3-7), or whether you are just referring to NAPL and chlorobenzene in the absence of the modeling. How are the modeling results used in this analysis?

Commented [GF49]: What is the evidence that these caps will be effective at containing NAPL?

Cap Placement

Cap material is assumed to be placed on the river bed using either a hydraulic diffuser or clamshell bucket.

Riverbank Areas

Armored caps are assumed to be placed at riverbanks where the slope exceeds 1.7H:1V and at riverbanks in the main channel that are prone to erosive forces. Vegetation is assumed to be ~~used for~~planted on riverbanks in off-channel areas that are not prone to erosion and with slopes less than 1.7H:1V.

Structures

Pilings, docks, berthing or mooring dolphins, and other structures servicing active wharfs or shore-based facilities will likely remain intact during remedial activities. Contaminated sediments and riverbank materials underneath and around these structures are assumed to be capped to the extent practicable.

Commented [GF50]: We would like EPA to seriously consider whether it is worthwhile to remove certain active structures, particularly to remove highly contaminated material. We understand that this decision will be made during design. However, we are concerned that the FS leaves too much flexibility to allow for minor active structures to remain in place in highly contaminated areas.

Other structures (such as dilapidated, obsolete or temporary structures) will be removed prior to capping activities. All structures with their foundations in contaminated sediments or riverbank materials and not servicing active wharfs or shore-based facilities will be removed prior to capping. All s~~S~~tructures located within Portland Harbor (both those that are planned for removal and those that are not) are shown on **Figure 3.3-23**. Removal of these structures will incorporate water quality controls to prevent the off-site transport of contaminated sediments.

Bioturbation Potential

Bioturbation is the displacement and mixing of sediment by burrowing or boring organisms. The extent bioturbation would affect the integrity of caps will be considered during the design phase. To prevent benthic organisms from disturbing the chemical isolation component of a cap, a bioturbation component of cap design is needed. According to data collected from surveys of benthic invertebrates in the lower Willamette River in October 2002 and July 2005, dipteran and oligochaetes are the most diverse taxonomic groups, while chironomids, oligochaetes, and bivalves are the most common groups. Burrowing depths of these organisms is approximately 4 to 10 centimeters (1.5 to 4 inches). To allow for uncertainty in burrow depths, a bioturbation layer of ~~a~~ 6 inches is assumed in the conceptual design of the engineered cap. This layer will reduce the potential for organisms to contact the underlying contaminated sediments or create preferential flow paths from the contaminated sediments, through the cap, to the surface water.

Ecological Habitat Areas

Shallow water habitat is a critical function of the river that~~n~~ must be retained. Adverse effects on overall habitat are important considerations during cap design and implementation. An engineered beach mix layer is applied to the uppermost layer of all caps in nearshore areas. This layer provides habitat and stability of the cap.

Shallow Areas

In shallow areas, placement of capping material will result in positive change in the bathymetry that would require mitigation under Section 404 of the Clean Water Act, and would also affect the flood rise capacity of the river. In order to limit the need for mitigation and flood rise analyses, equivalent cap thickness is dredged prior to placement to allow for a net zero bathymetry change in shallow areas.

3.3.3.6 Monitoring

Monitoring is an integral component of capping, and will be conducted to evaluate long-term effectiveness. The monitoring program will include sediment, surface water, pore water, and fish tissue samples collected at the following frequencies:

- Remedial Baseline Monitoring will be conducted prior to implementation of remedial activities to gage the performance of the remedy.
- Long-term Monitoring will commence the year following completion of remedy implementation and take place every 2-3 years for the first 10 years and once every 5 years thereafter until remedial goals are achieved.

3.3.3.7 Institutional Controls

Institutional controls (ICs) will be used to prevent or limit exposure to contaminants and ensure integrity of caps on both a short-term and long-term basis.

Waterway Use Restrictions or Regulated Navigation Areas (RNAs): Where caps will be utilized to contain contamination, waterway use restrictions or RNAs will be necessary to ensure the integrity of the cap is maintained. This will include prohibiting anchoring of vessels or the use of spuds to stabilize vessels in areas containing caps. Notifications such as signs and buoys placed by the Oregon Marine Board may be used to warn vessels from the area. RNAs have been successfully used in the past to protect remedial actions at the Site. RNAs were required to protect the McCormick and Baxter cap and the Gasco interim action cap from vessel activities. Periodic inspections of RNA notifications will be needed to ensure they are functional and effective.

Land Use/Access Restrictions: Land use or access restrictions may need to be implemented in nearshore areas and riverbanks to maintain the integrity of caps. DSL has promulgated administrative rules (OAR 140, Chapter 145) that control use of State-owned submerged or submersible land for activities related to a remedial action. Monitoring, including inspections, will be needed to ensure that restrictions are functioning as intended.

3.3.4 Removal Technologies

Two removal technologies were retained for assignment and further evaluation, dredging and excavation (see **Table 2.4-2**).

Commented [GF51]: It's not clear how this category is different from Ecological Habitat Areas, above. This should be clarified.

Commented [GF52]: Is seems that riverbanks should be included in this monitoring list as well.

Commented [GF53]: The area requiring RNAs will likely be orders of magnitude greater than the existing RNAs at the Site. The 5 Tribes are unsure about the extent to which the RNAs would affect vessel operation. We request that the Corps of Engineers be consulted during the FS phase to determine whether RNAs in the likely locations will be feasible. We would prefer their input early in the process instead of only after the Proposed Plan is released.

3.3.4.1 Dredging and Excavation Technologies

After remedy selection, the most appropriate and effective equipment would be determined during the design phase and used during construction. Several major considerations drive the conceptual design, cost estimates, and feasibility evaluation for the dredging included in the remedial alternatives, such as the following:

Mechanical Removal Equipment

Environmental/closed buckets are assumed for mechanical dredging of sediments to lessen releases to the water column. Articulated fixed-arm dredges are the preferred dredging option due to the greater bucket control that can be achieved with this dredge type versus cable-operated dredges. This greater bucket control has proven to limit contaminant resuspension and release at other sediment sites (AMEC et al. 2012).

Articulated fixed-arm dredges are assumed to have a maximum arm reach of 50 feet and bucket sizes ranging from approximately 2 cubic yards to 6 cubic yards, although bucket size decreases as arm length increases. A 4 cubic yard bucket size is assumed for all operations where bucket size is not limited by existing structures. A 2 cubic yard bucket ~~are~~ is assumed for dredging around and beneath existing structures.

Cable-operated dredges are assumed for those site conditions where fixed-arm dredges are not viable (such as water depths exceeding 40 feet) and will have no water depth limitations at the Site. Cable operated dredges are assumed to have a bucket size of 13 cubic yards.

Land-based excavators are assumed to be used for removal of contaminated riverbank materials or near-shore sediments in locations above water levels to limit offsite transport of disturbed riverbank materials by the river. The removal of riverbank material is assumed to be conducted in the late summer and early fall when river stage is low.

Productivity

The duration of the dredging season is assumed to be 123 days based on an in-water fish work window established for the Willamette River of July 1 through October 31. This in-water work window accounts for fish migration patterns and may be refined following discussions with the relevant technical experts from the natural resource trustees.

Dredging and excavation operations are assumed to occur 24 hours/6 days per week (Schroeder and Gustavson 2013). The daily and weekly durations of removal operations may be refined if community “quality of life” concerns (such as nighttime noise or light pollution) are identified.

Accuracy

Dredge prisms are defined as the continuous three-dimensional extent of sediment planned for removal. Limited data exists on the depth of contamination at the site. Core profiles showing depth of contamination for the focused COCs are presented on **Figures 3.3-30** through **3.3-35**. Consequently, a Natural Neighbors geostatistical interpolation was conducted using the existing subsurface data and assigning each pixel a depth to threshold corresponding to the deepest sediment sample with concentrations exceeding PRGs. The depth profiles within the SMAs from this interpolation are presented on **Figures 3.3-36a-f**. The volume of contamination in each SMA was calculated by summing the volumes (area of each pixel multiplied by its interpolated or measured depth to threshold) of the pixels in each SMA.

Dredge depths will be based on the RALs. A maximum dredge depth of 15-19 feet is assumed since special design and side slope stabilization considerations would need to be conducted on an area-specific basis. Nearshore areas encompass special habitat considerations so leave surfaces are assumed to be at the existing elevation. Therefore, any material removed would require backfill to the existing elevation. As dredge depths increase, volumes and costs for disposal of removed material increase as well as volumes and costs for fill material. It was determined that the optimal maximum dredge depth~~s~~ in nearshore areas was 3 feet to allow for the assumed thickness of an engineered cap.

If contamination above the RALs extends below the maximum dredge depth, a cap will be placed over the residual contamination. Otherwise, a 1 ft thick sand layer will be placed over the dredged area to cover the exposed surface and isolate any dredge residuals and remaining contaminated sediment inventory.

Single pass production dredging (one dredge pass to the appropriate depth followed by confirmation sampling) is assumed for all dredging areas, which is typical of modern dredging practices. A vertical accuracy of one foot was assumed for estimated depths; hence, a one-foot over-dredging allowance was used for volume estimates.

Riverbank Areas

It is ideal that riverbanks have a slope less than 5H:1V for habitat considerations. Many of the contaminated riverbanks currently have slopes that exceed this optimum ratio. Current industrial and commercial operations may have some structures that preclude obtaining this desired slope. Additionally, many of the contaminated river banks extend into the upland areas of the site that preclude removal of the contamination to PRGs. Consequently, caps will likely need to be placed on much of these banks and volumes are estimated by assuming that all the banks are currently vertical and need to meet a minimum slope of 1.7H:1V.

Release

Release is the mechanism by which dredging operations result in the transfer of contaminants from sediment pore water and sediment particles into the water column or air (USACE 2008b). Monitoring of water quality parameters will be conducted until applicable passing criteria are achieved. Monitoring programs, actions to address any water quality exceedances (such as increased dredge cycle times if water quality

Commented [GF54]: Editorial: Is this standard jargon? If so, please reword for lay reader.

Commented [GF55]: But it says below that the dredge depth in shallow areas is 5 feet if the RAL concentrations can be reached. It would be helpful to reference that exception here.

Commented [GF56]: How is this ideal slope factored into analysis if 1.7H:1V is used, as stated below?

Commented [GF57]: Editorial: Most commonly, “riverbank” (one word) is used in Section 3. However, occasionally “river banks” is used. We suggest you be consistent on this.

exceedances are resulting from dredging activities), and specific water quality criteria ~~to~~ will? be applied at the Site.

Residuals

Residuals refer to contaminated sediments remaining in or adjacent to the footprint after dredging is completed (Palermo et al. 2008). Recent field analyses at other sites have shown that the mass of contaminants released during dredging is typically one percent of the total contaminant mass removed, if the dredge residuals are capped soon after dredging and if dredging best management practices (BMPs) are implemented (Gustavson and Schroeder 2013). This is best ~~addressed~~ accomplished with a 6- to 12-inch layer of sand applied over the dredge area as soon as possible [i.e., promptly after the design dredge elevation has been met in greater than or equal to 95 percent of the dredging work area (adapted from Louis Berger Group 2010[1])]. Sediment cores are assumed to be taken through the post-dredge thin sand layer to confirm that the required layer of sand has been applied to manage residuals. These cores will be taken once the thin sand layers have been applied.

Commented [GF58]: The 5 Tribes are concerned about residuals and whether a 12-inch sand layer will sufficiently contain the residuals. We would like to see a cap model applied to residuals, using conservative (i.e., environmentally protective) assumptions about residual surface sediment concentrations post-dredging.

Contaminant releases in the absence of a post-dredge thin sand layer and operational BMPs are typically on the order of three percent of the total contaminant mass removed. A 12-inch sand layer is assumed for all dredge areas once 95 percent of dredging is complete (and the potential need for additional dredging passes to reach the desired dredge depth will be lessened) in an area to control residuals and releases. In areas where PTW is present, five percent activated carbon is assumed to be mixed with the residual layer.

Commented [GF59]: Editorial: Citation Gustavson and Schroeder?

Commented [GF60]: Editorial: The meaning isn't clear. The need for additional passes is lessened by the placement of the 12-inch sand layer?

During excavation, riverbank material will be susceptible to erosion from wind and surface water runoff. Erosion control measures are assumed to either divert surface water flows/runoff around and away from excavations or limit offsite transport of eroded riverbank materials. Sheet piles may need to be used to isolate ongoing excavations from erosive hydrodynamic forces if river stage increases during excavation. When sheet piles are not feasible (for example, where buried utilities are present), permeable berms (such as straw wattles) may be used.

Resuspension

Current velocities greater than 2.5 feet per second may limit the implementability and effectiveness of silt curtain controls, thereby increasing contaminant release rates/mass being transported away from the in-water work area during dredging activities (Palermo et al. 2008). However, dredging is assumed to occur during the approved in-water work window when river currents are low. Silt curtains are assumed to be feasible in current velocities less than 2.5 feet per second. Silt curtains are assumed in water depths less than 50 feet and in areas where NAPL is not present. A combination of silt and bubble curtains were unable to prevent multiple water quality criteria exceedances downstream

[1] Per Louis Berger (2010), "[a] dredging pass will be deemed to be successfully completed in a given sub-unit once 95% or more of the subunit is at or below the Depth of Contamination (DOC) elevation."

of the 2005 Gasco removal action involving NAPL (Parametrix 2006). Areas of confirmed NAPL presence and Site bathymetry are presented on **Figure 3.3-37**.

Commented [GF61]: Editorial: Terminology in figure is confusing – "above 50 ft" to mean -50 ft and shallower. Maybe something like "0 to -50 ft depth" and "greater than -50 ft depth"?

Engineered rigid control measures (such as sheet piles) may minimize NAPL and sediment releases outside of the sheet pile enclosed work area. These measures will be incorporated into any remediation alternative involving the presence of NAPL.

As evidenced by recent environmental dredging projects in the Pacific Northwest, dredging BMPs can greatly lessen contaminated sediment releases, residuals, and resuspension. The following BMPs have been effectively used at the Boeing Plant 2 portion of the Lower Duwamish Waterway Superfund Site (adapted from AMEC at al. 2012) and are assumed to be implemented at the Portland Harbor Site:

- Develop an accurate digital terrain model of sediment contamination depth.
- Develop a dredging plan, including over-dredge allowance, which will remove the targeted material in a single dredging event.
- Dredge each SMA to the required depth, verify with bathymetric surveys, and cover with a thin sand residuals layer.
- Ensure accurate bucket placement by using global positioning systems with sub-foot accuracy.
- Use stair-step dredge cuts to reduce sediment sloughing along steeper slopes.

Buried Debris and Pilings

Buried debris or denser sediment may impede removal of contaminated sediments and riverbank materials at the Site and will be removed. A standard clamshell bucket, grapple, or equivalent will be used for removal of this material. Appropriate controls specifically designed for debris or structure removal (for example, 2007 Puget Sound piling removal BMPs) will be used to lessen releases and dredge residuals. Areas containing debris and pilings are presented on **Figure 3.3-38**. Riverbank debris removal as part of the CERCLA remedy will be addressed during the design phase.

Commented [GF62]: We have not heard of the practice of removing denser sediment prior to general dredging. Does this refer to dense clay? Is this expected to be an issue at the Site? If not, consider removing this text.

Commented [GF63]: Editorial: Refer to these as "buried pilings" to distinguish from discussion of pilings below?

Structures

Pilings, docks, berthing or mooring dolphins, and other structures servicing active wharfs or shore-based facilities will likely remain intact during removal activities. To the extent practicable, a fixed arm environmental bucket dredge or excavator is assumed for removal of contaminated sediments and riverbank materials located beneath and around these structures.

Commented [GF64]: Similar to our earlier comment, the 5 Tribes would like this decision to be made on a case-by-case basis during design. It may be worth the cost of removing some active structures for the benefit of more effective sediment removal.

Other structures (such as dilapidated, obsolete or temporary structures) will be removed prior to environmental dredging or excavation activities. All structures with foundations in contaminated sediments or riverbank materials, and not servicing active wharfs or shore-based facilities, will be removed prior to dredging or excavation. Structures (both active and inactive) located within Portland Harbor are shown on **Figure 3.3-23**.

Removal of ~~these~~ inactive structures will incorporate water quality controls to prevent the off-site transport of contaminated sediments.

Flood Rise Concerns

Balancing of dredge and fill volumes will limit flood rise concerns throughout the Site.

Material Handling

Mechanical dredging is assumed for all sediment assigned for dredging. Dredged material is assumed to be loaded directly into barges and transported to shore for dewatering, treatment, or further transport. Sediment transport barges would be dewatered as necessary to prevent overflow and releases to the Willamette River. Materials removed during dewatering are assumed to be treated onshore. Riverbank materials excavated from above the water line are assumed to be loaded directly into containers for land-based transport and treated as needed.

Ex-Situ Treatment

CERCLA, the NCP and existing EPA guidance state a preference for treatment "to the maximum extent practicable," an expectation that "treatment [be used] to address the principal threats posed by a site, wherever practicable," and a preference for treatment "to the maximum extent practicable" while protecting human health and the environment. However, EPA guidance for PTW (USEPA 1991) acknowledges that some PTW may be safely contained and that treatment for all waste will not be appropriate or necessary to ensure protection of human health and the environment, or cost effective.

PCBs and dioxins/furans in sediment or riverbank soils are examples of PTW expected to be removed during the remedy. Concentrations of these contaminants that do not exceed regulatory standards that require treatment can be reliably contained in a landfill. The cost to dispose of this type of PTW material in an appropriate disposal facility without treatment (excluding removal or transport costs) can typically range from $30 to $100 per ton depending on the type of facility. While treatment of these contaminants would reduce their toxicity and mobility, it would also increase the volume and costs for disposal. The additional estimated cost for treating PCB and dioxin/furan contaminated sediment or riverbank soils prior to disposal at an appropriate facility can typically range from another $100 to $600 per ton, depending on factors such as the type of facility, concentrations of the contaminants, and treatment methods used to meet regulatory requirements. Thus, this material can be safely contained and the treatment of this waste prior to disposal would not be necessary to ensure protection of human health and the environment and would not be cost effective.

An additional evaluation will need to be conducted on dredged sediment containing any PTW related to NAPL, PAHs or DDx. Thus, ex-situ treatment is applied to dredged sediment and soil containing these contaminants.

3.3.4.2 Monitoring

Monitoring will be conducted to evaluate contaminant releases during dredging. The monitoring program will include surface water and air samples collected at the following frequencies:

- Remedial Baseline Monitoring will be conducted prior to implementation of remedial activities to gage the performance during dredging activities.
- Short-term Remedial Monitoring will be conducted regularly during implementation.

3.3.4.3 Institutional Controls

Institutional controls (ICs) will be used to prevent or limit exposure to contaminants during construction activities.

Fish Consumption Advisories: Fish consumption advisories would be required during dredging activities. Outreach would be conducted to educate the public about the fish consumption advisories. Informational materials and surveys of fish consumption patterns will be needed and evaluated to determine advisory effectiveness.

3.3.5 Sediment Disposal and Management

This section further develops specific disposal options retained through the technology screening process. Factors considered ~~as~~ in this analysis include regulatory requirements governing disposal, sediment contaminant characteristics, and disposal capacity. Commercial landfills and CDF technologies were retained through the screening process of on- and off-site disposal technologies in Section 2.4.2. The representative process options selected for each disposal technology for FS evaluation and cost purposes are:

- Commercial Landfills: Roosevelt Regional Landfill (Subtitle D), and Chemical Waste Management of the Northwest (Chem Waste) Landfill (Subtitle C; accepts RCRA waste)
- CDF: Terminal 4 CDF

The Off-Site Rule as set forth in the NCP (40 CFR §300.440) requires that CERCLA wastes transferred off of the cleanup site be placed in a facility operating in compliance with RCRA or other applicable Federal or State requirements. EPA determines the acceptability of a disposal facility based on relevant violations or releases and compliance with specific acceptability criteria identified in 40 CFR §300.440.

For the FS, each of the commercial landfills under consideration for disposal are assumed to be operating in compliance with their hazardous waste permits as required for CERCLA waste by the Off-Site Rule. Prior to disposal of CERCLA waste from the Site, the selected disposal facility's compliance with the Off-Site Rule will need to be verified with the EPA regional Off-Site Rule compliance contact before any material is

Commented [GF65]: We would like to see more detail here and in other monitoring sections. Approximately daily, weekly? Initially daily and then scaled back as appropriate based on results (e.g., adaptive management)? What about reporting of monitoring results? We understand that additional details will be provided in the Proposed Plan, but we would like a little more detail here.

Commented [GF66]: Given that fish consumption advisories are already in effect, we ask that you clarify if you mean "stricter" or some other difference. (This comment applies to the other Fish Consumption Advisories sections as well.)

transported for off-site disposal. The proposed disposal facility would also need to accept the wastes to be transported prior to disposal.

3.3.5.1 Types of Material or Waste and Regulatory Considerations

Several different types of contaminated material or waste could potentially be generated by dredging sediment from the Portland Harbor Site. Media contaminated by spills, leaks, discharges from outfalls, and migration through groundwater or stormwater is not generally solid or hazardous waste as defined by RCRA until managed as waste and disposed on- or off-site. If a listed or characteristic RCRA waste was generated and disposed of as part of historical operations at a site, then the contaminated media, such as sediment or soil, once managed as waste, may contain such regulatory waste and all on-site actions would need to comply with relevant RCRA storage, handling, and disposal requirements unless otherwise exempted under RCRA. Dredged material subject to requirements of a permit that has been issued under Section 404 of the CWA is excluded from the definition of hazardous waste [40 CFR 261.4(g)]. This provision is discussed in the Hazardous Waste Identification Rule (HWIR) (63 FR 65874, 65921; November 30, 1998). Oregon State adopted the HWIR rule in 2003. This rule means that RCRA regulatory requirements do not apply to sediment dredged at the Portland Harbor Site and disposed of on-site, such as at the Terminal 4 CDF, if the material otherwise meets the CDF acceptance criteria. However, disposal of dredged sediment would need to comply with the substantive requirements of the 404(b)(1) guidelines under the Clean Water Act [40 CFR Part 230, particularly the substantive requirements contained in Subparts B through F and H].

The expected regulatory waste types that may be generated include waste that contain RCRA characteristic hazardous wastes, RCRA- and State-listed hazardous wastes, and Toxic Substances Control Act (TSCA) waste. Additionally, dredged material that is not regulatory waste but has high concentrations or other characteristics requiring special disposal considerations will include “Waste or Media containing Waste that May Warrant Additional Management” and PTW (including PTW that cannot be reliably contained). Information about each of these waste types and their special handling and disposal requirements are discussed below.

RCRA Characteristic Hazardous Wastes

Sediment dredged from the Site will require waste characterization to determine whether it should be classified as material containing hazardous waste under RCRA. Preliminary analysis indicates that characteristic RCRA waste may be present at the Site.

A total of 11 sediment cores from eight areas were collected from the Site for Toxicity Characteristic Leaching Procedure (TCLP) analysis to determine if any sediment met the RCRA characteristic hazardous waste criteria for toxicity. Benzene concentrations exceeded the regulatory limit in one sample collected at the Gasco former MGP site. However, MGP wastes are by definition not RCRA hazardous wastes per 40 CFR §261.24(a), which specifically excludes solid MGP waste. While MGP wastes are exempted as a RCRA hazardous waste, concerns about the toxicity and mobility of the material prompted EPA to classify these materials as a “Waste or Media containing Waste that May Warrant Additional Management” at the Portland Harbor Site so the contaminated sediments could be appropriately handled and managed. “Waste or Media containing Waste that May Warrant Additional Management” are discussed in further detail below.

Additional TCLP testing was conducted as part of the Arkema 2009 EE/CA investigation (Integral and ARCADIS 2011). Lead, benzene, and TCE concentrations exceeded the TCLP criteria at one location for each contaminant, respectively. A review of chemical concentrations (particularly metals) across the Site indicates the potential for additional sediments to be classified as characteristic hazardous wastes based on the RCRA toxicity criteria.

Characteristic hazardous waste as defined in 40 CFR §261.24 will be subject to RCRA hazardous waste regulations (40 CFR Parts 260 to 268) if taken off-site for disposal. The design for the Terminal 4 CDF does not contemplate acceptance of RCRA characteristic hazardous waste due to contaminant mobility concerns. Therefore such waste will be taken off-site for disposal in the Chem Waste RCRA Subtitle C landfill unless contaminant concentrations exceed the land disposal restrictions specified in 40 CFR Part 268. In this case, treatment will be required as specified in 40 CFR §268.40 prior to disposal in the RCRA Subtitle C landfill. If sediment contaminant concentrations are less than acceptable land disposal restriction concentrations, then the material can be disposed of in the RCRA Subtitle C landfill without treatment.

RCRA and State-Listed Hazardous Wastes

Existing information was reviewed to assess whether there is historical knowledge of releases of listed hazardous wastes to Site sediment. Two areas of sediment were identified as potentially containing RCRA-listed hazardous waste and one area was identified as potentially containing Oregon State-listed hazardous waste. Certain sediments in the vicinity of the Siltronic NPDES outfall may contain RCRA F002-listed waste (non-industry specific spent solvent wastes) resulting from an accidental discharge of spent TCE to the Willamette River via an outfall. The other known area where RCRA-listed waste may occur is near the groundwater discharge zone at RM 6.9 West. This area may contain F027-listed waste (non-industry specific discarded unused formulations containing tri-, tetra-, or pentachlorophenol that have contaminated sediments). In addition, sediment adjacent to and downriver from the Arkema site may contain DDT-manufacturing waste residues. This material may be classified as an Oregon State-listed hazardous waste based on the Oregon Pesticide Residue Rule (Oregon Administrative Rule 340-109), and if taken off-site will be managed in accordance with the Oregon State regulations. Appropriate testing will need to be conducted to determine if sediment removed from the approximate areas shown on **Figure 3.3-39** contains these listed RCRA- or State-listed wastes.

If sediments containing RCRA-listed hazardous wastes are to be taken off-site for disposal, they must be stored and handled as a hazardous waste and can be disposed of in a RCRA Subtitle C landfill. Alternately, the material can be disposed of in a RCRA Subtitle D landfill if a contained-in determination has been obtained from the State and the material meets the requirements of the contained-in determination. If material classified as an Oregon State-listed hazardous waste based on the Oregon Pesticide Residue Rule is taken off-site for disposal, it may be managed in a RCRA Subtitle C hazardous waste facility, or it may be managed in a RCRA Subtitle D facility provided that the applicable land disposal concentration-based standards in 40 CFR §268.40 are met for waste pesticide containing any pesticide active ingredients listed in 40 CFR 261.33(e) and (f).

Where RCRA F002-listed waste (spent halogenated solvents) from the Siltronic site is found to be co-mingled with the Gasco MGP waste, the material will be classified as a RCRA listed hazardous waste for management and disposal purposes.

Waste or Media Containing Waste that May Warrant Additional Management

MGP-wastes in sediment adjacent to and downriver of the Gasco site but that fail the TCLP test are exempted as a RCRA hazardous waste. However, they may require special management and disposal due to contaminant toxicity and mobility. To support waste disposal suitability evaluations for sediments containing MGP-wastes, EPA developed a methodology to determine if any dredged sediment containing such wastes should be specially managed. This methodology relies on TCLP criteria for MGP-related contaminants to determine management and disposal requirements. Material that exceeds the TCLP criteria for the MGP-related contaminants will be identified as a "Waste or Media Containing Waste that May Warrant Additional Management." Any material so identified will be transported to and disposed of as a non-hazardous waste at a RCRA Subtitle C facility. However, if the material is treated and TCLP criteria are no longer exceeded after treatment, it may be disposed of in a RCRA Subtitle D facility.

TSCA Waste

In the event waste containing PCBs at concentrations exceeding the TSCA 50 mg/kg are generated, the waste is assumed to be disposed at a TSCA disposal site. However, PCB concentrations exceeding 50 mg/kg were not detected during the RI.

3.3.5.2 Sediment and Soil Disposal Framework

A sediment and soil disposal decision process was developed for the FS to assist in developing volumes and cost estimates for the various disposal options (**Figure 3.3-40)** based on sediment and soil contaminant characteristics. One important factor in the development of remedial alternatives is the volumetric capacity of the disposal options as compared to the volumes of sediment that may be removed from the Site. The capacities of the various disposal options are summarized in the following sections.

3.3.5.3 Upland Commercial Landfills

The capacity of the Roosevelt Regional RCRA Subtitle D facility is essentially unlimited relative to the volume of sediment expected to be dredged from the Site. This facility accepts a wide range of wastes and is permitted to accept materials with free liquid, and can accept wastes transported by rail, barge, or trucking. Roosevelt has moderately high tipping fees when compared to a RCRA Subtitle C facility. Because it is located in Washington State, additional regulations concerning the transport and disposal of materials, including consideration of State of Washington Dangerous Waste regulations will need to be addressed.

Material that is not acceptable for disposal in a RCRA Subtitle D facility will be disposed of at a RCRA Subtitle C Landfill. Only a small volume of dredged materials that do not meet RCRA Subtitle D acceptance criteria are expected to be generated. The capacity of the Chem Waste landfill example used in this FS is essentially unlimited with respect to the volume of hazardous wastes and other waste anticipated to be dredged from the Site for disposal in a RCRA Subtitle C facility. Wastes to be disposed of in this landfill must pass the paint-filter test. The Chem Waste Landfill can accept wastes transported by rail, barge, or trucking, and has the highest disposal costs. Wastes that may warrant special management considerations due to the nature of the waste may be considered for RCRA Subtitle C management to ensure long-term protectiveness.

3.3.5.4 Terminal 4 CDF

A conceptual plan of the proposed Terminal 4 CDF is shown on **Figure 3.3-41** and described in detail in 60 Percent Design (Anchor QEA 2011). Based on the current design, the capacity of the Terminal 4 CDF is 670,000 cubic yards of dredged contaminated sediments. This estimate does not include the volume that is expected to be gained due to consolidation settlement of the placed material and native sediment as the facility is filled. The current design analysis estimates that an additional 200,000 cubic yards of contaminated sediments capacity may be gained by consolidation. The volumetric capacity of the CDF relative to the estimated volume of sediment to be dredged from the Site and acceptable for placement is a factor in determining the viability of constructing a CDF. Approximately 150 percent of the 670,000 cubic yard volume capacity of the CDF, or approximately 1,005,000 cubic yards, was assumed to ~~to~~ be dredged from the Site to ensure sufficient quantity of material to justify the CDF's construction. By comparison, the ~~volumes~~ capacities? of the Roosevelt Regional Landfill and Chem Waste Landfill are approximately 90 million cubic yards and 247 million cubic yards.

EPA established CDF performance standards for use in evaluating CDFs during the FS. These address short-term impacts during CDF construction and filling, medium-term impacts during dormant periods between CDF filling seasons and before final closure, and long-term impacts following final closure of the CDF. A summary of how these standards were addressed in the T4 60 Percent Design are shown in **Table 3.3-8**. CDF acceptance criteria include the following:

- **No Hazardous Waste.** Sediments that would designate as RCRA or State hazardous waste, whether listed waste or characteristic waste are not eligible for placement in the CDF.

- **Waste or Contaminated Media Warranting Additional Management.** Sediments designated as a “Waste or Media containing Waste that May Warrant Additional Management” are not eligible for placement in the CDF due to concerns of contaminant mobility without adequate treatment. Such waste are not evaluated as eligible for placement in the CDF.

- **No PTW that is Highly Mobile.** Contaminated sediments identified as PTW that are highly mobile (cannot be reliably contained) are assumed to not be eligible for placement in the CDF without adequate treatment.

- **No Free Oil.** Sediments containing free oil or NAPL are PTW and not eligible for placement in the CDF.

- **Suitable Geotechnical Properties.** The geotechnical properties of the fill materials must be of an acceptable quality such that they do not affect the long-term performance of the CDF. Fill materials must be free of debris and significant organics, like wood chips, which could cause unacceptable obstructions, settlement, or gas generation.

- **Suitable Geochemical Properties.** The geochemical properties of the contaminated dredged sediments, primarily their leaching characteristics, must be shown to provide long-term protection of human health and the environment, and the beneficial uses of the Willamette River.

- **Other Considerations.** Other factors may be considered in determining acceptability of contaminated dredged material such as the physical nature of the material, nature of the chemical contaminants, and quantity of material.

Maximum contaminant concentrations in sediment suitable for placement in the CDF were derived in the T4 60 Percent Design (Anchor QEA 2011), and are provided in Appendix D.

3.3.6 Enhanced Monitored Natural Recovery

EMNR is accomplished through the placement of a 12-inch layer of sand, which is sufficient to allow for mixing with the underlying sediment bed, while also retaining clean sand above the mixed interval. In areas where PTW is present, 5 percent activated carbon is added to the sand layer.

Commented [GF67]: Why do we specify sand for EMNR and residuals throughout this document? There is potentially much more benefit to be gained from being a bit more inclusive and considering silty/clayey sands. Silts and clays and associated organic matter in a sandy material can greatly improve the filtering/sorptive capacity of the cap. Certainly very sandy materials have their advantages with ease of spreading, but from a source selection perspective we introduce an unnecessary and potentially unhelpful bias by using the terminology. Use of a more mixed sediment cap also has the potential to be a better match to the benthic system where most capping work is conducted, thus being more ecologically compatible sooner. We suggest considering using a more inclusive term like “predominantly sandy sediment”.

Commented [GF68]: The 5 Tribes are not confident that a 12-inch layer of sand (without additives) will sufficiently reduce risk within a reasonable timeframe. We would like to know what information was used to support the FS-level decision to use sand without additives in non-PTW areas.

3.3.6.1 Monitoring

Monitoring is an integral component of EMNR, and will be conducted to evaluate long-term effectiveness. The monitoring program will include sediment, surface water, pore water, and fish tissue samples collected at the following frequencies:

- <u>Remedial Baseline Monitoring</u> will be conducted prior to implementation of remedial activities to gage the performance of the remedy.
- <u>Short-term Remedial Monitoring</u> will be conducted every 2 years during implementation of remedial measures.
- <u>Long-term Monitoring</u> will commence the year following completion of remedy implementation and take place every 2-3 years for the first 10 years and once every 5 years thereafter until remedial goals are achieved.

3.3.6.2 Institutional Controls

Institutional controls (ICs) will be used to prevent or limit exposure to contaminants on both a short-term and long-term basis.

Fish Consumption Advisories: Fish consumption advisories would be required until such time as RAO 2 is achieved. Outreach would be conducted to educate the public about the fish consumption advisories. Informational materials and surveys of fish consumption patterns will be needed and evaluated to determine advisory effectiveness.

3.4 SWAN ISLAND LAGOON

Analysis of data collected during RI indicates that MNR is not occurring in Swan Island Lagoon at a rate sufficient to reduce risks within an acceptable time frame. There is limited water circulation within Swan Island Lagoon, limiting the rate of sediment deposition. Therefore, EMNR is being considered for the area in Swan Island Lagoon that is outside the SMAs and FMD areas to reduce risks. Where PTW is identified, treatment technologies will be also be assigned.

3.4.1 Enhanced Monitored Natural Recovery

EMNR is accomplished through the placement of a 12-inch layer of sand, which is sufficient to allow for mixing with the underlying sediment bed, while also retaining a clean sand above the mixed interval. In areas where PTW is also present, 5 percent activated carbon is added to the sand layer.

3.4.2 Monitoring

Monitoring is an integral component of EMNR, and will be conducted to evaluate long-term effectiveness. The monitoring program will include sediment, surface water, pore water, and fish tissue samples collected at the following frequencies:

- Remedial Baseline Monitoring will be conducted prior to implementation of remedial activities to gage the performance of the remedy.

- Short-term Remedial Monitoring will be conducted every 2 years during implementation of remedial measures.

- Long-term Monitoring will commence the year following completion of remedy implementation and take place every 2-3 years for the first 10 years and once every 5 years thereafter until remedial goals are achieved.

3.4.3 Institutional Controls

Institutional controls (ICs) will be used to prevent or limit exposure to contaminants on both a short-term and long-term basis.

Fish Consumption Advisories: Fish consumption advisories would be required until such time as RAO 2 is achieved. Outreach would be conducted to educate the public about the fish consumption advisories. Informational materials and surveys of fish consumption patterns will be needed and evaluated to determine advisory effectiveness.

3.5 REMAINING AREAS

All other areas of the site that exceed PRGs and have not been assigned a treatment technology will be addressed using natural recovery processes. Natural recovery typically uses ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment. These processes may include physical (sedimentation or dispersion), biological (biodegradation), and chemical (sorption and oxidation) mechanisms that act together to reduce the risks posed by contaminants.

3.5.1 Monitored Natural Recovery

MNR should be considered as a stand-alone remedy only when it would meet RAOs within a timeframe that is reasonable compared to remedies such as dredging and capping (USEPA 2005). Several of the factors affecting “reasonable” timeframes are present at the Site, and include the following:

- The extent and likelihood of human exposure to contaminants during the recovery period could be significant given the large expanse of the Willamette River and the various recreational uses of the river. ICs may be implemented at the Site but have limitations as discussed in Section 3.5.3, below.

- Significant ecological resources, including threatened and endangered species, exist within the Willamette River.

- Multiple uses of the river are ongoing; some of these uses such as navigation dredging, ship anchorage, fishing, etc. can affect contamination existing within surface and subsurface sediment.

- There is significant uncertainty with timeframe predictions for use of MNR as a stand-alone remedy.

For the purposes of the FS, it is expected physical isolation through natural deposition of cleaner material and dispersion and mixing are the primary mechanisms for natural recovery at the Site. MNR includes monitoring to assess the effectiveness of these natural processes ~~are occurring~~, but does not include physical remedial measures. Key aspects of the conditions for MNR are presented below.

3.5.1.1 Incoming Sediment Particle Concentrations

Analysis of upstream sediment trap and suspended solids data suggest incoming sediment COC concentrations are lower than sediment concentrations in the Site. As one example, upstream surface water sampling events conducted over a range of flow conditions at RM 16 found incoming suspended sediment particle PCB concentrations varied between 1.5 µg/kg and 23.6 µg/kg while the surface sediment concentrations at the site ranged from 0.851 J µg/kg to 35,400 µg/kg. This analysis suggests that MNR may be effective at some locations in Portland Harbor.

Commented [GF69]: Editorial: Is this a J qualifier, and, if so, is it intentionally included? It seems confusing to leave it in and would warrant an explanation.

3.5.1.2 Sediment Deposition Rate

The effectiveness of MNR will be dependent in large part on the rate of deposition. Two bathymetric surveys conducted in 2003 and 2009 were used in assessing whether areas at the Site were depositional. The typical bathymetric survey measurement error range is 0.5 feet, resulting in an uncertainty range of 1 foot for bed elevation changes between the two surveys. The uncertainty range in a single direction would be 6 inches, which equates to roughly 1 inch (2.5 cm) per year for the period between the May 2003 and January 2009 surveys. Therefore, a minimum deposition rate of 2.5 cm/year was assumed.

Commented [GF70]: Editorial: Was used as the criteria for effective MNR?

3.5.2 Monitoring

Monitoring is an integral component of EMNR, and will be conducted to evaluate the long-term effectiveness. The monitoring program will include sediment, surface water, pore water, and fish tissue samples collected at the following frequencies:

Commented [GF71]: Editorial: MNR?

- Remedial Baseline Monitoring will be conducted prior to implementation of remedial activities to gage the performance of the remedy.

- Short-term Remedial Monitoring will be conducted every 2 years during implementation of remedial measures.

- Long-term Monitoring will commence the year following completion of remedy implementation and take place every 2-3 years for the first 10 years and once every 5 years thereafter until remedial goals are achieved.

3.5.3 Institutional Controls

Institutional controls (ICs) will be used to prevent or limit exposure to contaminants on both a short-term and long-term basis.

Fish Consumption Advisories: Fish consumption advisories would be required until such time as RAO 2 is achieved. Outreach would be conducted to educate the public about the fish consumption advisories. Informational materials and surveys of fish consumption patterns will be needed and evaluated to determine advisory effectiveness.

3.6 DEVELOPMENT OF ALTERNATIVES

Remedial alternatives were assembled by combining the retained remedial technologies and process options identified in Section 2.4. Seven remedial alternatives were developed, including the no action alternative, based on the technology assignment assumptions presented in Sections 3.2 through 3.6. Consistent with EPA guidance (EPA 2005), a combination of remedial technologies and process options ~~have~~ has been assembled into each alternative to account for variability in conditions throughout the Site. This combined approach is expected to effectively protect human health and the environment and achieve RAOs and PRGs for the Site within a reasonable timeframe. All the alternatives, with the exception of Alternative A, would accommodate continued use of the navigation channel.

Remedial alternatives developed for this FS include the No Action Alternative (designated as Alternative A), as required by the NCP, and six remedial alternatives (designated as Alternatives B through G) that apply the same suite of remedial technologies and process options to varying degrees.

3.6.1 Common Elements

There are several elements common to Alternatives B through G. This section describes those common elements.

There are six distinct areas that will be addressed in each of the alternatives; the navigation channel (1,300 total acres), future maintenance dredge areas (241 total acres; 92 acres in Swan Island Lagoon and 149 acres in the main channel), intermediate areas (729 total acres), shallow areas (180 total acres), Swan Island Lagoon (113 acres), and river banks (26,141 total lineal feet). The navigation channel is the federally-authorized navigation channel. Future maintenance dredge areas (FMD) are those areas near and around docks based on information regarding vessel activity, dock configuration and future site uses where maintenance dredging is likely to occur (**Figure 3.3-15).** Intermediate areas are defined as outside the horizontal limits of the navigation channel and FMD areas to the bathymetric elevation of 4 ft NAVD 88. Shallow areas are defined as shoreward of the bathymetric elevation of 4 ft NAVD 88. River banks refer to those identified in Section 1.2.3.5.

Flowcharts of the technology assignment process are presented on **Figures 3.6-1(a-c)**. The primary differences between the alternatives is the size of the footprint of removal and containment based on the area of the SMAs defined for each alternative, as shown on **Figures 3.6-2(a-f) through 3.6-7(a-f)**. The area of each assigned technology is presented in detail in **Table 3.6-1** and summarized in **Table 3.6-2**. Additional information on material volumes is provided in **Tables 3.6-3** and **3.6-4**.

Navigation Channel

Contaminated sediment will be dredged to depth of the RAL concentrations (estimated as a maximum depth of 17 ft). If NAPL or PTW that is not reliably contained has been identified in a dredge area, a reactive residual layer is assumed. Otherwise, a residual layer is assumed.

Future Maintenance Dredge Areas

Contaminated sediment will be dredged to depth of the RAL concentrations (estimated as a maximum depth of 19 ft). If NAPL or PTW that is not reliably contained has been identified in a dredge area, a reactive residual layer is assumed. Otherwise, a residual layer is assumed.

Intermediate Areas

The maximum depth of contamination in this area is estimated to be 34 ft. Contaminated sediment will be dredged to the lesser of the RAL concentrations or 15 feet (assumed maximum depth since special design and side slope stabilization considerations would need to be conducted on an area-specific basis). If NAPL or PTW that is not reliably contained has been identified in a dredge area, then either an armored reactive cap or a reactive residual layer is assumed. Otherwise, a residual layer is assumed.

Shallow Areas

Contaminated sediment will be dredged to the lesser of the RAL concentrations or a maximum depth of 5 feet, and the dredged material will be replaced with an engineered cap to previous elevation. If the RAL concentrations are not expected to be reached within 5 feet~~Otherwise~~, the contaminated sediment will be dredged 3 feet and replaced with an engineered cap.

If NAPL or PTW that is not reliably contained is present within an SMA, the contaminated sediment will be dredged to the lesser of the RAL concentrations or 15 ft. The dredge prism is assumed to be replaced with a reactive residual layer, filled with sand to within 6 inches of the original elevation and the last 6 inches will be beach mix. If NAPL or PTW that is not reliably contained extends to depths greater than 15 ft, a reactive cap is assumed to be placed at the bottom of the dredge prism, the remainder of

Commented [GF72]: The following comments apply to Figure 3.6-1b. Some of these same comments also apply to Figure 3.6-1c.
1) If sediment is designated PTW, it should be actively remediated in some way. PTW outside an SMA that can be reliably contained should not be assigned MNR. At a minimum, EMNR should be assigned.
2) The many different types of caps will be confusing to the reader. We suggest a call-out box in the text or a companion “cheat sheet” to the flow charts describing each or depicting them in schematics (highlighting the differences).
3) We think there should be a decision point for within SMAs/under structures/PTW for whether the PTW is reliably contained. You assign reactive armored cap for all PTW in this situation, regardless of whether it can be contained. Perhaps it’s not feasible to construct a significantly augmented reactive cap under structures in shallow water, but “not reliably contained” should be a question anyway. Perhaps if there’s PTW that is not reliably contained under a structure, removal of the structure gets extra consideration.
4) The flowchart contemplates areas that are PTW but not SMAs. In what circumstances does this occur at the site? Would it be appropriate to define SMAs as areas exceeding RALs or areas where PTW is found?
5) “Heavy structure” is not defined in the text.
6) The terminology in the text and flow charts is confusing re: technology assignment. The title of the matrix figure is “technology assignment”. But then that gets brought over to the flowcharts as “matrix designation”, and “technology assignment” is used in a different way. In general, the idea of using the matrix first and then the flowcharts should be clearly stated upfront in the text.
7)It should be stated in the text that the technology assignments from the matrix aren't applied to shallow areas, or the later flowcharts overwrite the matrix designations. At least, this is our understanding of what EPA is doing. Perhaps shallow areas are even depicted as an off-ramp in the matrix flowchart, with a box directing readers to the shallow water flowchart.
The following comments apply to Figure 3.6-1a:
1) The legend is a bit confusing, especially the note. It should be clarified that testing to date has indicated no concentrations exceeding RALs below 18 ft/15 ft. And why don’t these depths match up with the text below (19 ft/17 ft)?
2) It seems that “Sediment concentrations” should instead say “RAL exceedances”.

Commented [GF73]: Editorial: This table appears to be missing the alternative names in the first column.

Commented [GF74]: Editorial: Cell D6 of this table – be sure to expand so entire text in cell is visible.

Commented [GF75]: We are assuming that this is after dredging occurs, but it might need to be stated. Do we expect NAPL/PTW at depths greater than 15 feet? If so, would the armored reactive cap be used, whereas the reactive residual layer would be used if the RAL has been achieved? If we are understanding the flowchart correctly, it looks like it indicates significantly augmented cap instead of armored reactive cap.

Commented [GF76]: The depth criteria is an important decision. The 5 Tribes would like to minimize capped areas to the extent practicable, in part to limit the amount of contamination left in place, and in part to limit areas of the river with use restrictions in perpetuity. We request an analysis that compares capping areas using greater depth criteria (e.g., 7 feet, 10 feet).

Commented [GF77]: Editorial: The existing sentence was not clear. Please review suggested edit to determine whether this captures your intention.

the dredge prism will be replaced with sand to within 1 ft of the previous elevation and the last 1 ft will be beach mix.

Commented [GF78]: Although it seems less likely that the material would migrate vertically through a reactive cap and other material totaling 15 feet in thickness, we are concerned about horizontal migration when proposing a cap over PTW that cannot be reliably contained. How will this be addressed during design?

If PTW that can be reliably contained is present within an SMA, contaminated sediment will be dredged to the lesser of the RAL concentrations or a maximum depth of 5 feet, and the dredged material will be replaced with a reactive residual layer, 3.5 feet of sand, and 6 inches beach mix. Otherwise, the contaminated sediment will be dredged 3 feet and replaced with an armored reactive cap.

Commented [GF79]: If RAL concentration is reached at less than 5 ft, say at 3 ft, the specified cap would increase the elevation. Is this your intention?

Commented [GF80]: Editorial: Similar to comment two paragraphs above, it's not clear what the "otherwise" refers to.

Riverbanks

If NAPL or PTW that is not reliably contained is present, a reactive armored cap is assumed.

Dredged Material

The sequence of dredging is assumed to be from RM 11.8 to RM 1.9.

Removed material that is considered for treatment is assumed to be treated at a nearshore upland facility that will be sited and constructed in remedial design.

The dredged material removed from the Site would be managed in accordance with one of the two disposed material management (DMM) scenarios:

- DMM Scenario 1: Confined Disposal Facility and Off-site Disposal. This scenario is only applied to Alternatives E through G because the estimated dredge volumes under these alternatives are adequate for placement in the CDF because they will not meet the 1,005,000 cubic yards of sediment threshold to justify construction of a CDF.

Commented [GF81]: Editorial: This seems to refer to Alternatives B-D. Was this meant to be a stand-alone sentence, and the first part was accidentally deleted?

- DMM Scenario 2: Off-Site Disposal. This scenario is applied to all alternatives.

Institutional Controls

Fish consumption advisories would be implemented after construction until PRGs are met. All caps will require waterway use or regulated navigation restrictions, and land use or access restrictions, long-term monitoring and O&M.

3.6.2 Alternative A: No Further Action

The No Action Alternative does not include any actions beyond the early actions implemented at the Gasco and Terminal 4 sites in 2005 and 2008, respectively. The Oregon Health Authority (OHA) would be expected to continue the fish consumption advisories already in place under State legal authorities, but the No Action Alternative does not include implementation of any new ICs or monitoring as a part of a CERCLA action for the Site.

3.6.3 Alternative B

This alternative involves dredging 81 acres to varying depths (614,130 to 818,830 cy), ex-situ treatment of 240,840 to 321,120 cy, capping 21 acres, EMNR of 103 acres, in-situ treatment of 7 acres, and MNR of 2,250 acres. The conceptual design for Alternative B is shown on **Figures 3.6-2a-f**. In-river construction duration for this alternative is estimated to be 4 years, with no additional time required to complete dredged material processing (i.e., dewatering and sampling for disposal parameters). The following alternative specific schedule dates have been estimated:

Commented [GF82]: The 5 Tribes believe that the construction estimates for the alternatives are unrealistically short. It seems very unlikely that dredging will occur 24 hours/day.

- Year 1: Establish initial conditions
- Year 1: Construction of on-site material handling/treatment facility
- Year 2: Start construction of remedial alternative
- Year 3: Dredging activities end
- Year 4: Placement of final material ends.

Under Alternative B, an estimated volume of 614,130 to 818,830 cy dredged material would be managed under DMM Scenario 2.

Estimated volumes of material[2] that would be needed for containment, dredge residuals management, and in-situ treatment are:

- Sand – 247,470 cy
- Beach mix – 9,240 cy
- Armor – 17,470 cy
- Activated Carbon – 5,190 tons
- Organoclay Mats – 15.3 acres

3.6.3.1 Navigation Channel

The estimated area to be dredged is 31 acres:

- 30 acres are dredged to 0-5 feet,
- 0.7 acres are dredged to 5-10 feet, and
- 0.1 acres is dredged to 10-15 feet.

Ex-situ treatment is assumed for 50,550 to 67,400 cy of the dredged material. In the areas dredged, 12 acres are covered with a reactive residual layer and 19 acres are covered with a residual sand layer.

Commented [GF83]: Editorial: Global change – should be dredged material throughout document.

3.6.3.2 Future Maintenance Dredge Areas

The estimated area to be dredged is 14 acres:

[2] All material quantities expressed as neat measurements.

- 12 acres are dredged to 0-5 feet,
- 2 acres are dredged to 5-10 feet, and
- 0.1 acre is dredged to 10-15 feet.

Ex-situ treatment is assumed for 67,830 to 90,440 cy of the dredge material. In the areas dredged, 14 acres are covered with a reactive residual layer and 0.4 acres is covered with a residual sand layer.

3.6.3.3 Intermediate Areas

The estimated area to be dredged is 23 acres:

- 14 acres are dredged to 0-5 feet,
- 6 acres are dredged to 5-10 feet, and
- 2 acres are dredged to 10-15 feet.

Ex-situ treatment is assumed for 273,440 to 364,590 cy of the dredge material. In the areas dredged, 22 acres are covered with a reactive residual layer and 0.1 acres are covered with a residual sand layer.

The area estimated to be capped is 9 acres: 5 acres of armored reactive cap, 1 acre of reactive cap, 3 acres of armored cap, and 1 acre engineered cap. The estimated area of in-situ treatment is 7 acres, with 10 acres of EMNR.

3.6.3.4 Shallow Areas

The estimated are to be dredged is 14 acres:

- 11 acres are dredged to 5 feet,
- 1 acre is dredged to 10 feet, and
- 1.5 acres are dredged to 15 feet.

Commented [GF84]: Are these meant to be 0-5, 5-10, and 10-15 (same comment for Shallow Areas sections within the subsequent alternatives as well)?

Ex-situ treatment is assumed for 123,120 to 164,160 cy of the dredge material. Within the dredged areas, 3.32 acres are estimated to be covered with an armored reactive cap, 1.5 acres with a reactive cap, 8 acres with a reactive residual cover, 2 acres with a residual cover, and 0.8 acres of armored reactive cap would be required under structures.

3.6.3.5 Riverbanks

In this alternative, 9,624 lineal feet of riverbank are assumed to be laid back to a slope of 5H:1V and covered with either an armored cap or an engineered cap using beach mix or vegetation. The volume to be excavated is estimated at 52,760 cy. Ex-situ treatment is assumed for 9,940 cy of the excavated material. The estimated area to be capped is 10 acres: 3 acres with a reactive armored cap, and 7 acres with a reactive cap. The following volumes of material are estimated be needed for containment, residuals management, and in-situ treatment:

- Sand – 29,680 cy
- Beach mix – 5,570 cy
- Armor – 4,520 cy
- Activated Carbon – 570 tons
- Organoclay Mats – 0.9 acre

3.6.4 Alternative C

This alternative involves dredging 100 acres to varying depths (762,000 to 1,016,000 cy), ex-situ treatment of 264,990 to 353,320 cy, capping 27 acres, EMNR of 101 acres, in-situ treatment of 5 acres, and MNR 2,232 acres. The conceptual design for Alternative C is shown on **Figures 3.6-3a-f**. In-river construction duration for this alternative is estimated to be 4 years, with no additional time required to complete dredged material processing. The following alternative specific schedule dates have been estimated:

- Year 1: Establish initial conditions
- Year 1: Construction of on-site material handling/treatment facility
- Year 2: Start construction of remedial alternative
- Year 4: Dredging activities end
- Year 4: Placement of final material ends.

Under Alternative C, an estimated volume of 762,000 to 1,016,000 cy dredged material would be managed under DMM Scenario 2.

The estimated volumes of material needed for containment, dredge residuals management, and in-situ treatment are:

- Sand – 313,960 cy
- Beach mix – 11,730 cy
- Armor – 22,820 cy
- Activated Carbon – 6,180 tons
- Organoclay Mats – 16 acres

3.6.4.1 Navigation Channel

The estimated area to be dredged is 38 acres:

- 36 acres are dredged to 0-5 feet,
- 1 acre is dredged to 5-10 feet, and

- 0.1 acre is dredged to 10-15 feet.

Ex-situ treatment is assumed for 58,330 to 77,770 cy of the dredge material. In the areas dredged, 13 acres are covered with a reactive residual layer and 24 acres are covered with a residual sand layer.

3.6.4.2 Future Maintenance Dredge Areas

The area estimated to be dredged is 18 acres:

- 16 acres are dredged to 0-5 feet,
- 2 acres are dredged to 5-10 feet, and
- 0.1 acre is dredged to 10-15 feet.

Ex-situ treatment is assumed for 100,210 to 133,610 cy of the dredge material. In the areas dredged, 17.5 acres are covered with a reactive residual layer and 0.5 acre are covered with a residual sand layer.

3.6.4.3 Intermediate Areas

It is estimated that 27 acres are dredged:

- 17 acres are dredged to 0-5 feet,
- 7 acres are dredged to 5-10 feet, and
- 3 acres are dredged to 10-15 feet.

Ex-situ treatment is assumed for 318,450 to 424,600 cy of the dredge material. In the areas dredged, 26 acres are covered with a reactive residual layer and 0.2 acres are covered with a residual sand layer.

The area estimated to be capped is 13 acres: 6 acres of armored reactive cap, 1 acre reactive cap, 4 acres of armored cap, and 2 acres engineered cap. The area of in-situ treatment is estimated to be 5 acres, with 10 acres of EMNR.

3.6.4.4 Shallow Areas

The estimated area to be dredged is 17 acres:

- 14 acres are dredged to 5 feet,
- 1 acre is dredged to 10 feet, and
- 2 acres are dredged to 15 feet.

Ex-situ treatment is assumed for 145,610 to 194,150 cy of the dredge material. It is also estimated that within the dredged areas the following residual covers are used: 4 acres armored reactive cap, 0.1 acre armored engineered cap, 2 acres reactive cap, 1 acre engineered cap, 10 acres reactive residual cover, and 2 acres residual cover. In addition, 0.1 acre of armored cap and 1 acre of armored reactive cap are estimated to be required under structures.

3.6.4.5 Riverbanks

In this alternative, 10,891 lineal feet of riverbank is assumed to be laid back to a slope of 5H:1V and covered with either an armored cap or an engineered cap using beach mix or vegetation. The volume to be excavated is estimated at 59,620 cy ~~is~~, ex-situ treatment is assumed for 9,940 cy of the excavated material. The area to be capped is estimated at 11 acres: 4 acres reactive armored cap, and 7 acres reactive cap. Estimates of the volumes of material needed for containment, residuals management, and in-situ treatment are:

- Sand – 34,230 cy
- Beach mix – 6,450 cy
- Armor – 4,840 cy
- Activated Carbon – 630 tons
- Organoclay Mats – 1 acre

3.6.5 Alternative D

This alternative involves dredging 152 acres to varying depths (1,172,920 to 1,563,900 cy), ex-situ treatment of 296,290 to 395,060 cy, capping 43 acres, EMNR of 88 acres, in-situ treatment of 3 acres, and MNR of 2,185 acres. The conceptual design for Alternative D is shown on **Figure 3.6-4a-f**. In-river construction duration for this alternative is estimated to be 5 years, with no additional time required to complete dredged material processing. The following alternative specific schedule dates have been estimated:

- Year 1: Establish initial conditions
- Year 1: Construction of on-site material handling/treatment facility
- Year 2: Start construction of remedial alternative
- Year 5: Dredging activities end
- Year 5: Placement of final material ends.

Under Alternative D, an estimated volume of 1,172,920 to 1,563,900 cy dredged material would be managed under DMM Scenario 2.

The estimated volumes of material needed for containment, dredge residuals management, and in-situ treatment are:

- Sand – 462,680 cy
- Beach mix – 16,930 cy
- Armor – 38,260 cy

- Activated Carbon – 8,650 tons
- Organoclay Mats – 16.8 acres

3.6.5.1 Navigation Channel

The area estimated to be dredged is 58 acres:

- 51 acres are dredged to 0-5 feet,
- 7 acres are dredged to 5-10 feet, and
- 0.1 acre is dredged to 10-15 feet.

Ex-situ treatment is assumed for 101,960 to 135,940 cy of the dredge material. In the areas dredged, 18 acres are covered with a reactive residual layer and 40 acres are covered with a residual sand layer.

3.6.5.2 Future Maintenance Dredge Areas

The area estimated to be dredged is 34 acres:

- 29 acres are dredged to 0-5 feet,
- 5 acres are dredged to 5-10 feet, and
- 1 acre is dredged to 10-15 feet.

Ex-situ treatment is assumed for 193,730 to 258,310 cy of the dredge material. In the areas dredged, 30.5 acres are covered with a reactive residual layer and 3.5 acres are covered with a residual sand layer.

3.6.5.3 Intermediate Areas

The area estimated to be dredged is 32 acres:

- 21 acres are dredged to 0-5 feet,
- 8 acres are dredged to 5-10 feet, and
- 3 acres are dredged to 10-15 feet.

Ex-situ treatment is assumed for 376,910 to 502,550 cy of the dredge material. In the areas dredged, 31 acres are covered with a reactive residual layer and 0.5 acre is covered with a residual sand layer.

The area estimated to be capped is 22 acres: 8 acres of armored reactive cap, 1 acre reactive cap, 9 acres of armored cap, and 4 acres of engineered cap. The area of in-situ treatment is estimated at 3 acres, with 8 acres of EMNR.

3.6.5.4 Shallow Areas

The area estimated to be dredged is 26 acres:

- 23 acres are dredged to 5 feet,
- 1 acre is dredged to 10 feet, and
- 2 acres are dredged to 15 feet.

Ex-situ treatment is assumed for 178,070 to 237,430 cy of the dredge material. In the areas dredged, the following residual covers are used: 6 acres armored reactive cap, 0.1 acre armored engineered cap, 2 acres reactive cap, 3 acres engineered cap, 12 acres reactive residual cover, and 4 acres residual cover. In addition, 0.1 acres of armored cap and 1 acre of armored reactive cap are estimated to be required under structures.

3.6.5.5 Riverbanks

In this alternative, 13,198 lineal feet of riverbank is assumed to be laid back to a slope of 5H:1V and covered with either an armored cap or an engineered cap using beach mix or vegetation. The estimated volume to be excavated is 72,640 cy, ex-situ treatment is assumed for 9,960 cy of the excavated material. The area estimated to be capped is 13 acres: 4 acres of reactive armored cap, 8 acres of reactive cap, and 1 acre engineered cap. The estimated volumes of material needed for containment, residuals management, and in-situ treatment are:

- Sand – 42,580 cy
- Beach mix – 7,990 cy
- Armor – 5,640 cy
- Activated Carbon – 720 tons
- Organoclay Mats – 1 acre

3.6.6 Alternative E

This alternative involves dredging 236 acres to varying depths (2,061,390 to 2,748,520 cy), ex-situ treatment of 323,670 to 431,560 cy, capping 67 acres, EMNR of 59 acres, and MNR of 2,121 acres. The conceptual design for Alternative E is shown on **Figure 3.6-5a-f**. In-river construction duration for this alternative is estimated to be 7 years, with no additional time required to complete dredged material processing. The following alternative specific schedule dates have been estimated:

- Year 1: Establish initial conditions
- Year 1: Construction of on-site material handling/treatment facility
- Year 1: Construction of CDF (if used)
- Year 2: Start construction of remedial alternative
- Year 6: Dredging activities end
- Year 7: Placement of final material ends.

The dredged material removed from the Site under Alternative E would be managed in one of two disposal scenarios:

- DMM Scenario 1:
    - 1,737,720 to 2,316,960 cy to the onsite CDF
    - 323,670 to 431,560 cy to off-site disposal facilities
- DMM Scenario 2:
    - 2,061,390 to 2,748,520 cy to off-site disposal facilities

The estimated volumes of material needed for containment, dredge residuals management, and in-situ treatment are:

- Sand – 712,000 cy
- Beach mix – 26,390 cy
- Armor – 60,810 cy
- Activated Carbon – 14,490 tons
- Organoclay Mats – 17.7 acres

3.6.6.1 Navigation Channel

The estimated area to be dredged is 78 acres:

- 68 acres are dredged to 0-5 feet,
- 9 acres are dredged to 5-10 feet, and
- 0.1 acre is dredged to 10-15 feet.

Ex-situ treatment is assumed for 135,200 to 180,260 cy of the dredge material. In the areas dredged, 26 acres are covered with a reactive residual layer and 52 acres are covered with a residual sand layer.

3.6.6.2 Future Maintenance Dredge Areas

The area estimated to be dredged is 71 acres:

- 51 acres are dredged to 0-5 feet,
- 18 acres are dredged to 5-10 feet,
- 1 acre is dredged to 10-15 feet, and
- 0.5 acre is dredged to 15-19 feet.

Ex-situ treatment is assumed for 560,580 to 747,440 cy of the dredge material. In the areas dredged, 63 acres are covered with a reactive residual layer and 8 acres are covered with a residual sand layer.

3.6.6.3 Intermediate Areas

The area estimated to be dredged is 45 acres:

- 30 acres are dredged to 0-5 feet,
- 11 acres are dredged to 5-10 feet, and
- 5 acres are dredged to 10-15 feet.

Ex-situ treatment is assumed for 548,130 to 730,840 cy of the dredge material. In the areas dredged, 43 acres are covered with a reactive residual layer and 1 acre is covered with a residual sand layer.

The area estimated to be capped is 34 acres: 14 acres of armored reactive cap, 2 acres of reactive cap, 13 acres of armored cap, and 5 acres of engineered cap. The area of in-situ treatment is estimated at 0.1 acre, with 7 acres of EMNR.

3.6.6.4 Shallow Areas

The area estimated to be dredged is 41 acres:

- 38 acres are dredged to 5 feet,
- 0.5 acre is dredged to 10 feet, and
- 3 acres are dredged to 15 feet.

Ex-situ treatment is assumed for 284,600 to 379,470 cy of the dredge material. It is also estimated that within the dredged areas the following residual covers are used: 10 acres armored reactive cap, 0.1 acre armored engineered cap, 3 acres reactive cap, 3 acres engineered cap, 22 acres reactive residual cover, and 4 acres residual cover. In addition, 0.1 acre of armored cap and 2 acres of armored reactive cap are estimated to be required under structures.

3.6.6.5 Riverbanks

In this alternative, 16,048 lineal feet of riverbank is assumed to be laid back to a slope of 5H:1V and covered with either an armored cap or an engineered cap using beach mix or vegetation. The volume to be excavated is estimated at 89,210 cy, ex-situ treatment is assumed for 9,970 cy of the excavated material. The area estimated to be capped is 16 acres: 5 acres of reactive armored cap, 10 acres of reactive cap, and 1 acre engineered cap. The estimated volumes of material needed for containment, residuals management, and in-situ treatment are:

- Sand – 50,410 cy
- Beach mix – 8,960 cy
- Armor – 7,590 cy
- Activated Carbon – 920 tons

- Organoclay Mats – 1.1 acres

3.6.7 Alternative F

This alternative involves dredging 424 acres to varying depths (4,382,540 to 5,843,380 cy), ex-situ treatment of 371,870 to 495,830 cy, capping 140 acres, EMNR of 24 acres, and MNR of 1,913 acres. The conceptual design for Alternative F is shown on **Figure 3.6-6a-f**. In-river construction duration for this alternative is estimated to be 12 years, with no additional time required to complete dredged material processing. The following alternative specific schedule dates have been estimated:

- Year 1: Establish initial conditions
- Year 1: Construction of on-site material handling/treatment facility
- Year 1: Construction of CDF (if used)
- Year 2: Start construction of remedial alternative
- Year 11: Dredging activities end
- Year 12: Placement of final material ends.

The dredged material removed from the Site under Alternative F would be managed in one of two disposal scenarios:

- DMM Scenario 1:
  - 4,010,660 to 5,347,550 cy to the onsite CDF
  - 371,870 to 495,830 cy to off-site disposal facilities
- DMM Scenario 2:
  - 4,382,540 to 5,843,380 cy to off-site disposal facilities

The estimated volumes of material needed for containment, dredge residuals management, and in-situ treatment are:

- Sand – 1,340,410 cy
- Beach mix – 40,350 cy
- Armor – 147,100 cy
- Activated Carbon – 17,360 tons
- Organoclay Mats – 19.4 acres

3.6.7.1 Navigation Channel

The estimated area to be dredged is 178 acres:

- 135 acres are dredged to 0-5 feet,
- 37 acres are dredged to 5-10 feet,
- 5 acres are dredged to 10-15 feet, and

- 0.2 acre is dredged to 15-17 feet.

Ex-situ treatment is assumed for 183,090 to 244,120 cy of the dredge material. In the areas dredged, 34 acres are covered with a reactive residual layer and 144 acres are covered with a residual sand layer.

3.6.7.2 Future Maintenance Dredge Areas

The estimated area to be dredged is 129 acres:

- 73 acres are dredged to 0-5 feet,
- 52 acres are dredged to 5-10 feet,
- 4 acres are dredged to 10-15 feet, and
- 0.5 acre is dredged to 15-19 feet.

Ex-situ treatment is assumed for 693,270 to 924,360 cy of the dredge material. In the areas dredged, 71 acres are covered with a reactive residual layer and 59 acres are covered with a residual sand layer.

3.6.7.3 Intermediate Areas

The estimated area to be dredged is 52 acres:

- 27 acres are dredged to 0-5 feet,
- 17 acres are dredged to 5-10 feet, and
- 8 acres are dredged to 10-15 feet.

Ex-situ treatment is assumed for 701,820 to 935,750 cy of the dredge material. In the areas dredged, 44 acres are covered with a reactive residual layer and 6 acres are covered with a residual sand layer.

The estimated area to be capped is 89 acres: 27 acres of armored reactive cap, 2 acres of reactive cap, 47 acres of armored cap, and 13 acres of engineered cap. The area estimated to be treated in-situ is 0.1 acre, with 4 acres of EMNR.

3.6.7.4 Shallow Areas

The estimated area to be dredged is 65 acres:

- 62 acres are dredged to 5 feet,
- 0.5 acre are dredged to 10 feet, and
- 3 acres are dredged to 15 feet.

Ex-situ treatment is assumed for 314,240 to 418,980 cy of the dredge material. It is also estimated that within the dredged areas the following residual covers are used: 17 acres armored reactive cap, 1 acre armored engineered cap, 7 acres reactive cap, 14 acres engineered cap, 18 acres reactive residual cover, and 11 acres residual cover. In addition, 0.5 acre of armored cap and 2 acres of armored reactive cap are estimated to be required under structures.

3.6.7.5 Riverbanks

In this alternative, 19,633 lineal feet of riverbank is assumed to be laid back to a slope of 5H:1V and covered with either an armored cap or an engineered cap using beach mix or vegetation. The volume to be excavated is estimated at 108,060 cy, ex-situ treatment is assumed for 9,970 cy of the excavated material. The estimated area to be capped is 20 acres: 7 acres of reactive armored cap, 11 acres of reactive cap, and 2 acres of engineered cap. The estimated volumes of material needed for containment, residuals management, and in-situ treatment are:

- Sand – 59,390 cy
- Beach mix – 9,760 cy
- Armor – 10,970 cy
- Activated Carbon – 1,170 tons
- Organoclay Mats – 1.1 acres

3.6.8 Alternative G

This alternative involves dredging 617 acres to varying depths (6,865,250 to 9,153,660 cy), ex-situ treatment of 388,510 to 518,010 cy, capping 236 acres, EMNR of 15 acres, and MNR of 1,655 acres. The conceptual design for Alternative G is shown on **Figure 3.6-7a-f**. In-river construction duration for this alternative is estimated to be 18 years, with no additional time required to complete dredged material processing. The following alternative specific schedule dates have been estimated:

- Year 1: Establish initial conditions
- Year 1: Construction of on-site material handling/treatment facility
- Year 1: Construction of CDF (if used)
- Year 2: Start construction of remedial alternative
- Year 17: Dredging activities end
- Year 18: Placement of final material ends.

The dredged material removed from the Site under Alternative G would be managed in one of two disposal scenarios:

- DMM Scenario 1:
    - 6,476,740 to 8,635,650 million cy to the onsite CDF
    - 388,510 to 518,010 cy to off-site disposal facilities

- DMM Scenario 2:
  - 6,865,250 to 9,153,660 million cy to off-site disposal facilities

The estimated volumes of material needed for containment, dredge residuals management, and in-situ treatment are:

- Sand – 2,030,620 cy
- Beach mix – 58,900 cy
- Armor – 250,820 cy
- Activated Carbon – 20,320 tons
- Organoclay Mats – 19.7 acres

3.6.8.1 Navigation Channel

The estimated area to be dredged is 297 acres:

- 195 acres are dredged to 0-5 feet,
- 93 acres are dredged to 5-10 feet,
- 8 acres are dredged to 10-15 feet, and
- 0.5 acre is dredged to 15-17 feet.

Ex-situ treatment is assumed for 207,200 to 276,270 cy of the dredge material. In the areas dredged, 47 acres are covered with a reactive residual layer and 250 acres are covered with a residual sand layer.

3.6.8.2 Future Maintenance Dredge Areas

The estimated area to be dredged is 163 acres:

- 78 acres are dredged to 0-5 feet,
- 78 acres are dredged to 5-10 feet,
- 6 acres are dredged to 10-15 feet, and
- 1 acre is dredged to 15-19 feet.

Ex-situ treatment is assumed for 726,790 to 969,060 cy of the dredge material. In the areas dredged, 78 acres are covered with a reactive residual layer and 85 acres are covered with a residual sand layer.

3.6.8.3 Intermediate Areas

The estimated area to be dredged is 61 acres:

- 32 acres are dredged to 0-5 feet,
- 19 acres are dredged to 5-10 feet, and

- 10 acres are dredged to 10-15 feet.

Ex-situ treatment is assumed for 763,280 to 1,017,710 cy of the dredge material. In the areas dredged, 44 acres are covered with a reactive residual layer and 15 acres are covered with a residual sand layer.

The estimated area to be capped is 162 acres: 36 acres of armored reactive cap, 2 acres of reactive cap, 100 acres of armored cap, and 24 acres of engineered cap. The area estimated to be treated in-situ is 0.1 acre, with 2 acres of EMNR.

3.6.8.4 Shallow Areas

The estimated area to be dredged is 89 acres:

- 86 acres are dredged to 5 feet,
- 0.5 acre is dredged to 10 feet, and
- 3 acres are dredged to 15 feet.

Ex-situ treatment is assumed for 327,440 to 436,590 cy of the dredge material. It is also estimated that within the dredged areas the following residual covers are used: 18 acres armored reactive cap, 1 acre armored engineered cap, 10 acres reactive cap, 25 acres engineered cap, 18 acres reactive residual cover, and 19 acres residual cover. In addition, 1 acre of armored cap and 2 acres of armored reactive cap are estimated to be required under structures.

3.6.8.5 Riverbanks

In this alternative, 22,700 lineal feet of riverbank is assumed to be laid back to a slope of 5H:1V and covered with either an armored cap or an engineered cap using beach mix or vegetation. The volume to be excavated is estimated at 123,580 cy, ex-situ treatment is assumed for 9,970 cy of the excavated material. The estimated area to be capped is 23 acres: 7 acres of reactive armored cap, 12 acres of reactive cap, and 4 acres of engineered cap. The estimated volumes of material needed for containment, residuals management, and in-situ treatment are:

- Sand – 69,420 cy
- Beach mix – 12,020 cy
- Armor – 11,940 cy
- Activated Carbon – 1,240 tons
- Organoclay Mats – 1.1 acres

3.7 SCREENING EVALUATION OF ALTERNATIVES

The screening criteria conform to the remedy selection requirements set forth in Section 121 of CERCLA, the NCP [40 CFR 300.430(e)(7)], and the RI/FS Guidance (USEPA

1988). Since it is required under the NCP that the no action alternative is used in the detailed evaluation and comparative analysis, Alternative A is not screened in this section. As stated above, Alternative B through G all use the same combination of technologies to differing degrees. The three criteria used for the initial screening of alternatives are effectiveness, implementability, and cost.

Effectiveness

Commented [GF85]: According to 40 CFR 300.430(e)(7), effectiveness includes the question of how quickly the alternative achieves protection. We think that this factor should be mentioned here, especially given that it seems it is one of the primary differences between the alternatives.

Reductions in the site-wide SWAC were estimated by assuming the alternatives achieve an ideal constructed surface concentration of zero. A post-construction site-wide SWAC was calculated and compared to the current site-wide SWAC. These results are presented in **Table 3.7-1**. All the alternatives are effective in reducing risks from COCs at the site. Alternative B relies on less construction and more MNR to reduce risks and each alternative thereafter relies on more construction and less MNR.

Implementability

A comparison of the estimated acres assigned to each technology and cubic yards of dredging and b~~a~~orrow material for the alternatives is presented in **Table 3.7-2**. All alternatives are implementable, with the amount of construction increasing from Alternative B through Alternative G.

Commented [GF86]: Editorial: It would be helpful to define borrow material earlier (when first describing volumes of the different types of borrow material) or here.

Cost

Cost is proportional to the amount of construction and materials needed for each alternative. Thus, costs increase from Alternative B to Alternative G.

EPA RI/FS guidance (USEPA 1988) notes that the entire range of alternatives originally developed do not need to be carried through the detailed analysis if all alternatives do not represent distinct viable options. Based on the information provided in the screening tables of the alternatives, Alternative C was eliminated from consideration of the detailed analysis in Section 4. This decision is primarily due to the small incremental increase in quantities of dredge and borrow materials between Alternatives B and C, and the relatively small incremental decrease in focused COC concentrations when compared between Alternatives B and D or C and D. The differences between Alternatives B and C include only a 0.1 percent increase in overall acres remediated with only a corresponding average 9 percent reduction of focused COC concentrations in surface sediment. Thus, it was concluded that Alternative C was not distinctly different from Alternative B. All other alternatives are carried forward for detailed analysis in Section 4.

REFERENCES

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